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Notes on the Internal Improvements of the Continent of Europe.

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Within the last few years, internal improvements, principally railroads, have made very great progress upon the continent of Europe. The example given first by Great Britain, and later, on a much larger scale, by the United States of North America, could not fail to attract the attention of other people and governments. The important influence of facilitated internal communications upon the prosperity of a country could no longer be doubted; all prejudices against their introduction were gradually vanquished, and the spirit of enterprize and speculation became awakened. We now see extensive lines of railways already completed, and others in progress, in different parts of the continent of Europe, and at no distant period we may expect to see connected *by* them all the capitals and other important cities of the numerous states and provinces, in which this large territory is divided.

Although the United States are already provided with a system of railroads, the extent of which far exceeds that of all railroads executed in all the other parts of the globe, a notice of the works undertaken and accomplished in Europe cannot be without interest to the readers of this journal, and principally to the engineer, who may find in the history of every railroad, in the description of its locality and construction, and of the difficulties overcome, something new and in-

structive. In the following notes, for which the data were carefully collected on the spot, and may be relied on as correct, it is intended to give a short description of the works of internal improvement executed, or undertaken and in progress, in different states of the continent, in the order in which they were examined.

Having during a long stay become possessed of detailed information concerning all the railroads now in operation and in progress in Austria, I am enabled to commence the present communication with a full description of the internal improvements in that empire, though my notes may not be as complete respecting the other European States.

LETTER I.

VIENNA, 1st of September, 1841.

Internal Improvements of the Austrian Empire.

Geographical notice—Navigation—Steam navigation upon the Adriatic and Mediterranean, upon the Danube—Canals in Italy and Hungary; the Vienna and Newstadt Canal—Turnpike roads—Lintz and Gmunden—Prague and Pilsen railroads—Emperor Ferdinand's northern road—Vienna and Raab railroad—First Hungarian railroad from Presburg to Tyrnau—Milan and Montza—Milan and Venice railroads—Railroads projected; Bohemian coal road, Prague and Dresden, Vienna and Trieste railroads, central railroad of Hungary, Bochnia and Lemberg railroad.—Extent of railroads completed, in progress, and projected, in Austria.

The Austrian empire occupies the central part of the European continent, and covers the one thirteenth part of its surface. In regard to area Austria ranks the third amongst the European States, being inferior only to Russia and the United Kingdoms of Sweden and Norway; in regard to population it ranks the second, as it is surpassed only by the Russian empire. Austria extends from 42° 9′ to 51° 2′ north latitude, and from 26° 14′ to 44° 45′ east longitude, (the meridian over the island of Ferro taken as the first,) or over 8° 53′ from south to north, and 18° 21′ from west to east. It is bounded by twelve different sovereign states, of which, however, some are very small. The longest boundary line is towards Turkey, viz. 1,550 miles, while the length of boundary towards all the surrounding states is 4,166 miles. To this must be added the length of sea coast on the Adriatic, which (the islands excepted,) measures 1,248 miles, making the total length of boundary, or the circumference of the empire equal to 5,414 miles. Considerable as this length of the sea coast may appear, its advantages in regard to commerce are much diminished by the peculiar situation, form, and distance from the main body of the Austrian empire.

The monarchy of Austria is composed of sixteen large provinces, inhabited by nations different in origin and language, viz: of eight kingdoms, one Archduchy, (Austria, of which the empire bears the

name,) four Duchies, one grand Principality, one Margraviate, and one Principality—county. The following table contains the area and population of the different provinces.

Name of Province.	Area in square miles.	Population in 1837.	Inhabitants to the square mile.
Archduchy of Austria,	15,725	2,168,694	138
Duchy of Styria,	9,055	935,576	103
Kingdom of Illyria,	11,430	1,195,874	105
Kingdom of Bohemia,	21,155	4,001,925	189
Margraviate of Moravia with Silesia,	11,050	2,074,246	188
Kingdom of Galicia,	35,510	4,518,360	127
Kingdom of Hungary and vicinal provinces,	92,990	11,138,942	120
Grand Principality of Transylvania,	24,705	2,170,392	88
Military boundary districts,	13,550	995,861	73
Kingdom of Lombardy, Venice,	18,505	4,534,197	245
Kingdom of Dalmatia,	5,210	373,479	72
Principality, county of Tyrol.	11,475	814,892	71
	270,360	34,922,438	129

This population did not include the army; with the latter it was 35,398,438. At present (1841,) the population of the whole Austrian monarchy is computed at 36,500,000 souls, equal to 135 per square mile. Only a part of the Austrian empire belongs to Germany; the area of the Austrian German provinces is 79,880 square miles, and their population, 11,613,280. The standing army of Austria consists in 324,000 soldiers.

By the Adriatic the Austrian empire is brought in contact with the sea, and in direct communication with foreign ports. Trieste, Venice, and Fiume, are the three principal sea ports of Austria, from which an active trade is carried on, not only along the coast of the Adriatic, but also with the principal ports of Italy, France, and Spain, Greece, Asia minor, and Egypt. *Trieste*, the most important port of the three, exports principally the products of the German provinces of Austria; *Venice*, once the queen of the seas, the centre port for the Indian trade, before the passage round the Cape of Good Hope was discovered, is now of minor importance, although it has been a free port several years; it exports the products of the Italian provinces. *Fiume* commands only a small trade; it is the principal port on the Adriatic, for the Hungarian provinces, with which, however, it is connected only by very bad roads. There are at present in Austria

516 vessels for distant voyages, with a tonnage of		105,400 tons.
1320 large coasters,	"	48,300 "
1345 small " or rather boats,	"	10,200 "
	Total tonnage,	163,900 "

Only from three to six Austrian vessels go annually from the Aus-

trian sea ports to London; about as many to the different ports of the North Sea and the Baltic; from nine to twelve make voyages to Brazil, and from fifteen to seventeen to the United States of North America. The greatest part of the foreign trade with Austria continues to be carried on by foreign vessels.

During the latter years a great impulse was given to the trade of the Mediterranean by the introduction of steam navigation, in which Austria did not remain behind. Regular trips are now made between Trieste and Venice, Trieste and Constantinople, Trieste and Ancona, &c., as also between Constantinople and the ports of Syria and Egypt. The steam navigation company of the Austrian Lloyd at Trieste, now own eleven steamboats, and the following have been their operations in 1840.

Voyages. 1840.	Number of trips.	Passengers number.	Freight, cwt.*	Packages, pieces.	Specie and precious articles, amount.	Letters, number.	Income. Dollars.
Between Trieste and Constantinople,	24	9,661	38,359	7,206	$1,764,763	10,062	219,274
" Constant., Valo, Salonica, Alexandria, and Syria,	22	6,465	2,416	185	110,254	2,162	
" Trieste and Venice,	155	15,053	9,199	10,892	4,038,942	5,786	62,276
" Trieste and ports of Dalmatia,	20	2,569	2,047	3,168	254,452	1,555	9,488
" Trieste, Ancona, and other ports of Italy.	64	5,138	1,364	230	106,913	559	12,805
	285	38,886	53,385	21,681	6,275,324	35,087	313,843
In 1839	245	27,930	40,566	15,561	5,481,563	23,251	

* One Austrian cwt. = 100 Austrian lbs. = 123½ English lbs.

The expenditure of the company for the year 1840 has been:

For loading and unloading, port and consul duties,	$ 17,234
Salaries, board of crew, repairs, and sundry disbursements,	107,803
Fuel: coal and wood,	85,764
Administration,	54,398
Total,	$ 265,199
Net profit,	48,644
	$ 313,843

Austria is traversed by many navigable rivers, but only few of them offer great facilities for internal communication. The principal river

of the Austrian empire, the mighty Danube, has a course of more than 2,000 miles of length, of which 850 miles are in Austria; it forms the natural highway to the Black Sea and the Orient. Until it reaches the plains of Hungary the current of the Danube is very rapid, having through a great part of Austria an average speed of five to six feet per second, or about four miles per hour. The width of the river is unequal; near Vienna, for instance, it is 18,000 feet, or 3.4 miles; at Belgrade, only 3,160 feet; at the "iron Port," 500 feet, and at Orsova, where the Danube leaves the Austrian territory, the width is 2,053 feet. The swiftness and changeableness of current, the shallowness in many places, winding course, cliffs, &c., offer great obstacles to navigation, especially up stream. Nevertheless, thousands of boats come down and up the river to Vienna, with provisions, and all kinds of agricultural and mineral products.

The importance of the introduction of steam navigation upon the Danube was felt at an early period, and as early as in 1819 attempts were made to that effect. Want of experience and of confidence, however, for a time, retarded their success; in 1830, a chartered company took the matter in their hands, and in the following year (1831,) the performances of the first boat, "Francis I," proved the practicability of steam navigation upon the Danube. In 1832 two steamboats made regular trips between Raab, Pest, and Semlin, in Hungary; in 1834 the "Argo" went the first over the rapids at the "Iron Port," and arrived safely at Galatz. Subsequently steam navigation was extended up the Danube, from Vienna to Lintz, and through Bavaria to Ratisbon.

The steam navigation company's boats now make regular passages throughout the navigable season between Lintz, Vienna, Pest, Semlin, Galatz, Varna, Constantinople, Trebisond, Salonica, and Smyrna. A passage from Vienna to Constantinople requires twelve days, and costs, in the first cabin, 62½ dollars, in the second cabin, 42½ dollars, and on deck, 28 dollars, exclusive of board.

In 1840 the company had in operation ten river boats and seven sea boats; at the same time they were building five new boats for 1841, making the total number twenty-two. The number of passengers carried by all the steamboats, in the year 1840, was 125,293; the quantity of freight, = 20,482 tons; the income from all sources has been:

From the ten river boats,	- - -	$ 175,135
" seven sea boats,	- - -	123,953
" discounts, &c.,	- - -	4,469
	Total,	$ 303,557

Amount brought forward, - - -	303,557
The current expenses during the year amounted to	154,145
Leaving as net profit, - - -	$ 149,412

The capital stock of the company consists in 7,560 shares at 250 dollars, or in 1,890,000 dollars; the net profit in 1840 was therefore 7.9 per cent. on the capital invested.

How much the business done by the steamboats is on the increase, will be seen from the following numbers, showing the traffic from 1837 to 1840, inclusively:

	Year 1837	1838	1839	1840.
Passengers,	47,436	74,584	105,926	125,293
Tons of freight,	4,111	17,812	19,388	20,482

The steamboats used upon the Danube and the Black Sea, are all built on the English model; two of them, the "Sophia" and "Stephan," are of iron. The "Sophia" has two low pressure engines of sixty horses power each, and goes only three feet deep when loaded. She is used exclusively upon the upper Danube, between Vienna and Lintz, where navigation is most difficult. A trip down from Lintz to Vienna, a distance of 144 miles, is performed in nine hours, or at the rate of sixteen miles per hour, while a trip up, from Vienna to Lintz, requires not less than thirty-two to thirty-six hours, and sometimes more. The fuel used is coal, from the vicinity of Pilsen, in Bohemia, and costs, delivered at Lintz, eight dollars and ten cents per ton. Another company, chartered in the kingdoms of Bavaria and Wurtemberg, run their boats between Lintz and Ratisbon, in connection with those in Austria.

A new impulse will be given to the steam navigation of the Danube by the different railroads now in progress in the vicinity of this river, but still more by the "Maine and Danube Canal," in Bavaria, which approaches its completion. This canal, of which I shall take occasion to speak in my subsequent letters, is 108 miles in length, and connects the Danube, near Ratisbon, with the Maine at Bamberg; the latter river is to be improved for steam navigation to its mouth at Mentz, whence numerous steamboats are running upon the Rhine to Rotterdam and the German Ocean. On the completion of the canal, an uninterrupted connection by water will exist between the North Sea, or German Ocean, and the Black Sea, certainly one of the most magnificent lines of internal communications in the world.

Besides the steamboats upon the Danube and the Adriatic, there are only a few boats upon some of the minor rivers and lakes in Austria. A small boat has lately been started upon the Moldau at Prague, to run between that city and Dresden; she draws only sixteen inches water, but can, nevertheless, come up to Prague only at

high water, the Moldau being too shallow through a great part of the year. A great deal remains to be done in Austria in the improvement of rivers and the extension of navigation upon them. Steam navigation may, in fact, be regarded here as in its infancy, if compared with the high degree of perfection it has attained in the United States, where it originated.

Canals.—There are comparatively few canals in the Austrian empire, and most of them are in the kingdom of Lombardy—Venice, (Italy.) The following are the principal ones: the "Naviglio Grande," which connects the Ticino river and the Lago maggiore with Milan, length twenty-seven miles; the "Martezana" Canal connects the Adda, and thereby the Como lake, with Milan, and is twenty-six miles in length. The "Naviglio nuovo" extends from the Naviglio grande, at Milan, to the Ticino, at Pavia, whence by means of the Po river a connexion is effected with the Adriatic; length, nineteen miles. Many other canals of different lengths traverse the country, but serve, for the greatest part, only for irrigation.

In Hungary we have the "Francis Canal," which unites the Danube with the Theiss; it was executed between the years 1793 and 1802, by a company of stockholders, at a cost of 1,500,000 dollars; length, sixty-eight miles. The "Bega Canal," of seventy-five miles in length, serves to improve the navigation of the Bega.

There is only one canal in the other Austrian provinces, which serves for the transportation of goods, viz: the "Newstadt Canal," which extends from Vienna through Lower Austria to the frontier of Hungary. This canal was undertaken by a company in 1797, with the object of connecting Vienna with Trieste; afterwards it was resolved to extend it only to the coal mines near Oedenburg, in Hungary. In 1800, the government took charge of the works, and finished the canal to the frontier of Hungary, in a length of forty-five miles, in 1803. The extension to the coal mines at Oedenburg, (fourteen miles,) was not acceded to by the Hungarians.

The total ascent from Vienna to the other terminus of the line is 328 feet, the number of locks, fifty. The canal is thirty feet wide on the surface of the water, and four feet deep. The locks are eighty-seven feet in length, and built partly of cut stones, partly of bricks, the latter are now re-built with stones. The width of the locks is only eight feet. The boats used upon this canal are eighty feet long, and only six feet wide; they draw three feet water with their maximum load of twenty-five tons.

Since 1822, the canal is leased by the government; the present contractor pays an annual rent of 6,540 dollars, and has to keep the canal, boats, &c., in perfect order. The principal articles transported

upon this canal are bricks, wood, coal, and some merchandize; nearly all the freight is in coming down to Vienna, and the boats return back empty. The contractor of the canal is bound to forward all articles at a fixed tariff, from the 1st of April to the 30th of October, but generally the navigation of the canal is open during eight months in the year.

The contractor furnishes the boats, men, and horses, and charges to the owner of the goods so much per *load*, or per cwt. For a load of fire wood, (about eleven cords weighing eighteen tons,) the charge is for the whole distance, (forty-five miles,) fifteen dollars, or at the rate of 1.85 cents per ton per mile. The charge for coal is ninety-three cents per ton, (2,000 lbs.) for the whole distance, or 2.07 cents per ton per mile; for merchandize from Neustadt to Vienna, (thirty-eight miles,) one dollar and twenty cents, equal to 3.16 cents per ton per mile. Up to Neustadt the charge is only eleven dollars per load, or eighty cents per ton = 2.11 cents per ton per mile—6,000 bricks are reckoned a load.

There are carried annually, over the canal, about

10,000,000 of bricks, weighing	47,000	tons, (of 2,000 lbs.)
30,000 cords of fire wood,	55,000	"
Stone coal, - - -	2,500	"
Merchandize, - -	800	"
Total,	105,300	tons.

For a trip from Vienna to Neustadt and back, three days are required; the boat is drawn by one horse, and served by three men; the pilot, whose daily wages are nineteen cents; the bowsman, who receives eighteen cents, and the driver, who gets twenty cents per day. The boatmen furnish the horse, and receive for it fifteen cents per day, besides food. At present the number of boats used upon the canal is seventy; the number of arrivals at Vienna during the year 1840 was 6,339. The cost of a new canal boat is 200 dollars.

The contractor of the canal has not only to keep the canal, buildings, &c., in perfect repair, but also to re-build the old brick locks. There are thirty-four lock tenders on the line, each of whom receives twenty cents per day; the maintenance of the whole canal costs, annually, near 15,000 dollars.

There are many remarkable structures on the Neustadt Canal which deserve to be noticed, such as the fifty-eight stone bridges by which the communication between the two banks is entertained; the fifty locks, of which eight are within the city of Vienna, where, on a length of nearly two miles, the banks of the canal are protected by

perpendicular stone walls; the large basin at the terminus in Vienna, where the boats are unloaded; several large aqueducts, of which those near Baden and Neustadt are the most prominent, &c., &c.

Turnpike Roads.—Extensive is the system of turnpike roads, with which the Austrian empire is covered. Nearly all the provinces are traversed in many directions by well constructed and well maintained roads, built, for the greatest part, at the expense, and under the direction of the government. Leading from city to city, they connect all the different parts of the monarchy with each other, and with the adjoining countries, not impeded even by those numerous giant mountains, which seem to put an eternal barrier to all communications between the countries separated by them. We mention in the following only the principal lines. Regarding Vienna as the centre of the empire, the great commercial roads are:

1. That from Vienna to the Adriatic in several branches, passing the Semmering on an elevation of 3,920 feet, and the Loibl mountain on an elevation of 4,360 feet. Distance from Vienna to Trieste, 336 miles.

2. The road from Vienna to Lintz, the capital of Upper Austria, and from there to Bavaria in one, and to Innspruck, Verona, and Mantua, in another direction, passes over the Alps and surmounts the Brenner, at an elevation of 4,646 feet. Distance from Vienna to Mantua, 490 miles.

3. From Vienna to Prague there are two roads; distance, 188 miles. From Prague numerous turnpikes lead to different parts of Germany.

4. A turnpike leads from Vienna over Presburg, Raab, &c., to Buda and Pest, from there to Hermanstadt and the Walachia, and over Peterwaradin to Semlin and Belgrade, as also over Debretzin to Clausenburg. Distance from Vienna to Belgrade, (Turkey,) 490 miles; to Cronstadt, (Transylvania,) 627 miles.

5. The road from Vienna to Lemberg, the capital of Galicia, and from there to Brody, on the frontier of Russia. Length, 590 miles.

6. From Vienna over Oedenburg, Agram to Carlstadt, and continued to Fiume and Zara, in Dalmatia. Distance to Zara, 400 miles.

In regard to the difficulties overcome in their construction, the following deserve particularly to be mentioned, the road from Carlstadt to Fiume, constructed in 1809, which surmounts a summit of 3,120 feet in height, and is nevertheless used by the heaviest wagons; the military road over the Stilfserjoch mountain, built from 1820 to 1825, at an expense of 1,450,000 dollars; it extends from Bormia to Tyrol, where it connects with the road to Innspruck, and is the highest known pas-

sage over the Alps, as the summit of the Stilfserjoch is 9,536 feet high, and therefore elevated above the snow region.

In the same manner as the great commercial roads are connecting the metropolis of the empire with the capitals of the provinces, the provincial roads connect these latter with other less important towns, and by these lateral roads new extensive connexions are again formed. All these roads were constructed, and are maintained by the government, which expends annually, for this purpose, from two to three millions of dollars. The cost of maintenance is partly sustained from the tolls collected.

Constructed in a less expensive and durable manner, but still more extensive are those roads which are built and maintained by the communities; they form innumerable branches to the commercial and provincial roads, and extend the facilities of intercourse to the very door of the agriculturist. Most of these roads are to be found in the kingdom of Lombardy—Venice; while in Hungary, on the contrary, very little has been done yet in this respect. According to statistical data the following is the extent of roads in the different provinces of Austria, with the exception of Hungary and the adjoining provinces.

Name of province.	Turnpike roads built and maintained by government.	Other roads.	Total length of roads.
	Miles.	Miles.	Miles.
Lombardy—Venice,	2,580	18,590	20,970
Illyria,	870	2,300	3,170
Bohemia,	2,000	5,220	7,220
Austria,	1,175	3,920	5,095
Tyrol,	790	1,460	2,250
Styria,	475	2,155	2,630
Monravia and Silesia,	565	2,800	3,365
Galicia,	1,735	520	2,255
Dalmatia.	170	390	560
	10,360	37,155	47,515

[TO BE CONTINUED.]

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Force of the Wind and Sea, observed at the Delaware Breakwater in* 1830 *and* 1831, *with some suggestions concerning the transverse sections of Breakwaters. By* ELLWOOD MORRIS, *Civil Engineer.

That the force of the sea and wind often operates with tremendous energy against objects which resist their action, is a fact well known; to measure this force with precision is from the nature of things impossible, and hence it is only by a close attention to the observed

effect produced by the waves of storms, upon opposing objects, that the engineer is enabled to form a proper idea of the energies of an agitated sea, when roused by gales to the assault of works raised for the protection of harbours.

To form a well sheltered harbour upon a site fairly exposed to the ocean, is one of the most difficult problems which can be proposed for solution by the engineer, for such is the difficulty of forming a stable barrier against the sea, that notwithstanding all that has been done in erecting sea-works under the direction of the ablest minds, we can at this day scarcely, if at all, point to an artificial harbour in a dangerous roadstead, which has realized the expectations of its projectors.

To appreciate, properly, the active forces which we are to countervail, is the first step in framing plans for sea-works; and to add another to the number of observed facts bearing upon this subject, is the object of the present article.

In the years 1830 and 1831, the writer (then assistant engineer at the Delaware Breakwater,) had occasion to notice particularly, the severity of the action of storms upon such portions of that work as were then elevated above low water mark; the results of these observations we will now detail, merely premising first such brief account of the work itself as seems necessary to a full understanding of the subject.

The Delaware Breakwater was located and begun in 1829; it will, when finished,* consist of two detached dikes of rock, *the Breakwater proper*, a work of 1200 yards in extent, running in a line tangent to the seaward extremity of Cape Henlopen, and commencing at 500 yards distant therefrom; the *ice-breaker*, a work 500 yards long, lying obliquely across the prolongation of the line of the Breakwater, and distant from its western end 350 yards, at the nearest point; the Breakwater lies nearly in the original course of the ebb tide, trending E. S. E. and W. N. W., and will cover the harbour from the northern and eastern winds; whilst the ice-breaker (mainly designed to shelter the anchorage from ice drifting on the ebb,) bears E. by N. and W. by S., and will, at the same time, protect the interior from the winds of the north-west quarter; the contained angle between the horizontal projections of the two works being thirteen of the southern points of the compass, or 146¼°.

This artificial harbour is located in Cape Henlopen road, just within the pitch of the Cape, and its site is fully exposed to the sea-winds which blow directly in from the Atlantic ocean, over the whole arc

* If it be completed upon the plan projected by Com. Rodgers, Gen. Bernard, and W. Strickland, Esq., Commissioners; and approved by President J. Q. Adams, on the 27th of Februray, 1829.

comprised between E. S. E. and N. E. by N. around by the East, measuring seven compass points, or 78¾°; whilst on the other hand, it is also exposed to winds sweeping an extent, for the most part, of deep water, upon lines of twenty miles long in the Delaware Bay, and including, in their field of action, the whole arc contained between the N. E. by N. and W. S. W., around by the West, being thirteen points, or 146¼°; from the W. S. W. around by the South to E. S. E., an arc of twelve points, or 135°; the roadstead is completely landlocked by the shoals of Broadkill, and the main strand in front of the town of Lewes, Sussex county, Delaware.

From the above statement it is evident that the roadstead under Cape Henlopen is wholly exposed to the winds of the north-east quarter, the severest that blow upon the American coast, and which fling upon the strand within the Cape those tremendous billows which are raised by the sweep of the north-east gales over a free range of ocean; whoever has witnessed the fury of these storms upon our sea-coast, will, from these remarks, appreciate the violence of the seas which sweep that perilous road, wherein the writer has himself seen fourteen sail of vessels stranded at the same time, and with the loss of several valuable lives.

The average rise and fall of the tide in Cape Henlopen road is five feet, the highest spring tides, in moderate weather, seven feet, whilst the highest storm tides have been known to attain an altitude of ten feet and more above the plane of low water.

Previous to the month of August 1830, the ice-breaker, at its eastern or seaward end, had been brought up to the shape sectionally indicated by Figure 1; in the centre of the top a stone pier was erected, its shape, a frustrum of a pyramid, 14½ feet long, two and a half feet square in the middle, and weighing seven tons; this was firmly secured on every side by split stone stays of one and a half tons weight, well laid and packed, and the whole of the work then appearing above the water had a flat slope seaward, and was as firmly and compactly formed as was possible with large and rough stone laid without mortar; in the centre of the top of the stone pier (which was elevated ten feet above high water,) a light flag-staff, some twenty feet long, was fixed in a vertical socket, upon a wrought iron pintle fourteen inches long and one and a half inches in diameter.

Figure 1 exhibits the appearance of the work as formed previous to a severe north-east gale which occurred in August 1830.

Figure 2 exhibits the appearance of the work immediately after the gale referred to.

Both of the figures are sketched from measurements made by the writer at the time, and in both O, is the line of common high water, and P, the low water plane.

During this gale a number of heavy stones were swept from the top of the work, and the chief part of the split stone stays, weighing one and a half tons each, were torn from their beds, and transported forty feet to the westward; the stone pier was canted to an angle of 30° with the vertical, and would undoubtedly have been driven over the harbour slope, and lost, if the gale had continued longer; the flag-staff, by the force of the wind and the crests of the billows which swept the work, was forced into the position shown in figure 2, and the wrought iron pintle supporting it, of one and a half inches diameter, *was bent to a right angle!*

The stone pier was soon after replaced, the work rebuilt, and in October, 1830, when the operations of that season terminated, it had been brought up to the shape indicated by the strong or upper lines of Figure 3, the greatest care having been taken to form the whole top surface into a heavy pavement, sloped seaward with a gentle declination, compactly laid, and well wedged with spalls of stone driven by hammers into every crevice; the lower, or broken line of Figure 3, shows the outline of the work as actually found in April, 1831; the storms of the winter of 1830 having denuded the whole space between the two lines, and swept off down the harbour slope, the stone pier of seven tons weight, its split stone stays averaging one and a half tons each, and more than 200 tons of other stone,* many of which exceeded a ton in weight, few being under a quarter of a ton, and all having been previously wedged and compacted together, as has been described.

Thus was the ice-breaker dismantled by the furious winter sea of 1830, whilst the Breakwater proper also suffered severely during the same time; a stone pier of the same dimensions and weight as that we have already described, was landed upon the top of the Breakwater late in the season of 1830, but from want of time was not

* Similar effects have often been produced by storms upon other Breakwaters; thus we find it stated in De La Beche's Geological Manual, that "during the severe gales of November 1824, and again at the commencement of 1829, blocks of lime-stone and granite, from two to five tons weight, were washed about on the Breakwater at Plymouth, *like pebbles;* about 300 tons, in blocks of these dimensions, being carried a distance of two hundred feet, and even up the inclined plane of the Breakwater."

"These blocks were thrown over on the other side, where they remained after the gale scattered in various directions. A block of lime-stone, weighing seven tons, was washed round the western extremity of the Breakwater, and carried 150 feet."

As the experience of the action of the sea upon the Breakwater at Cherbourg was of the same character, it seems unnecessary to quote it; the tendency of the whole is to show that the present mode of relying upon heavy pavements, for the security of the summits of Breakwaters, does not answer the purpose, whilst it seems to inculcate the necessity of forming the coping of such works of a mass of stone of great depth, *so bonded as to gravitate as one body;* as is suggested in a subsequent part of this paper.

erected, and was left laying with its top surface level with high water mark; during a gale of wind in the early part of December of that year, it was moved, broadside foremost, about eighteen feet, and finally in a storm upon the 15th of January, 1831, together with many other heavy stones, it was precipitated down the harbour slope and lost; this work, when closely inspected by the writer, in April 1831, showed that a great many of the surface stones had been arranged by the action of the sea, with their longer axes tending towards the point of the strongest wind, or to the north-east, with their ends often lapping over each other, in form slightly resembling the shingling of a house, and after attaining this position they appeared generally to have maintained it, though it was evident enough that many others had been swept away.

The storms which produced the effects we have recited, though severe, were not remarkably so, and have, without doubt, often been surpassed in violence, by those tremendous easterly storms, which, at intervals of a few years, devastate our coast.

The effects which we have recorded were produced by adequate causes, of which they are in some sort the measure; and it may perhaps be neither uninteresting nor unimportant, in a professional point of view, to enter briefly into a discussion of the mode of action of the sea waves against opposing obstacles, and the proper section which it appears to prescribe for the summits of Breakwaters.

In this connexion the first thing we have to consider is the probable maximum altitude of the waves of the sea. Arnott, in his "Elements of Physics," in referring to the billows created in the ocean at a distance from the land, observes that "no wave rises more than ten feet above the ordinary sea level, which, with the ten feet that its surface afterwards descends below this, gives twenty feet for the whole height, from the bottom of any water valley to an adjoining summit."

This estimate is probably correct, though other writers have asserted that the altitude of the highest waves from the trough to the crest, reaches thirty, or even according to some, fifty feet;* but when we reflect that all the circumstances of a storm at sea tend to inflate our ideas of the magnitude of what takes place, such statements must be received with caution.

Where waves approach a sloping coast, they are borne up by the submerged land, they mount higher, as upon an inclined plane, and finally combing over at the crest, discharge themselves in breakers upon the beach.

* See the number of this Journal for August, 1836. Since writing the above the writer has been informed that the late Frence Exploring Expedition determined this question very accurately in the midst of the Pacific ocean, and fixed the maximum height of waves at 22 feet.

The justly celebrated Smeaton, in his account of the building of the Eddystone Lighthouse, informs us, that during, and immediately after, a severe storm, the billows of the ocean, borne up by the inclined strata of the rocks of the Eddystone, mount to such a surprising altitude as actually to envelope the lantern, at a height of more than eighty feet above the usual surface of the sea, and comb over it, in form similar to the prodigious jet of water which is projected ninety feet into the air, from the great Geyser in Iceland.

Returning from this digression upon the phenomena of waves, we will observe that in the case of Breakwaters, rising abruptly as they do from the bottom of the sea, it seems probable that the augmentation of altitude which waves receive in running upon an inclined coast, is not produced by them, or if at all, in but a slight degree.

The stones forming the summits of Breakwaters, when assailed by the waves of the sea, are solicited by two forces, one acting vertically upward, with the force due to the hydrostatic pressure of a column of water, equal in altitude to the maximum wave which assails the work, and which force we can estimate; the other is the horizontal force due to the progressive motion of the billows, the extent of which we have no means of determining.

We may make a practical application of these views as follows; the heaviest stone used in the construction of the Delaware Breakwater, consisting of Trap rock, from the Palisades on the Hudson river, weighed 184 lbs. to the cubic foot; whilst the lightest, being the Hornblende rock, from Quarryville, in the northern part of the State of Delaware, weighed but 165 lbs. to the cubic foot;* the average weight of the materials being 175 lbs. per cubic foot, or two and seventh-tenth times heavier than sea water.

Let us assume, according to Arnott, the maximum altitude of waves to be twenty feet, then if we take the case of the Delaware Breakwater, where the storm tides rise ten feet, let *a*, in the annexed sketch, Figure 4, be the top level of the storm tide, *b*, the plane of low water, *c*, the dry rubble foundation of the work thrown promiscuously from vessels into the water, *d*, a mass of stone lying upon the rubble foundation, with its base coincident with the plane of low water, and

* The Hornblende rock referred to, as weighing 165 lbs. to the cubic foot, was the Greenstone from Jaque's quarry. A specimen of Gray Gneiss, from one of Leiper and Crosby's quarries, was found at the same time to weigh 168 lbs. to the cubic foot; and some Black Gneiss from Hill's quarry, on Crum Creek, weighed 177 lbs. per cubic foot. All the specimens of the above rocks, of which the specific gravity was tried by the writer, were broken off from masses of stone delivered at the Delaware Breakwater, in the construction of which all these varieties were then used. The specific gravities of some specimens of similar rocks, from the same quarries, were subsequently found by a committee of the Franklin Institute, to be somewhat greater than is above stated.

e, a wave of twenty feet high, advancing from sea at high water in the direction of the arrow, the crest rising ten feet above the high water plane, and the trough falling ten feet below it; then it is manifest that though whilst the wave is upheaving near the margin of the work, it may not act very powerfully upon substances in front of its base, yet the moment it begins to subside, if it happens to be in the position indicated in the sketch, with its fore foot inserted under the mass of stone, *d*, it will exert upon that mass the upward hydrostatic pressure due to a head of twenty feet, and in an instant after the horizontal force due to the progressive motion of the wave; and thus, as it were, *by successive pulsations*, the waves possess the power of advancing forward immense masses of rock.

Now the upward hydrostatic pressure of a column of sea water twenty feet high, would equal the gravity of a mass of stone weighing 175 lbs. to the foot, if the vertical thickness of the latter were $= \frac{20}{2\frac{7}{10}}$, or near seven and a half feet;* *consequently, if the depth or thickness of the mass of stone were less than seven and a half feet, it would be advanced a little to leeward by each successive wave; but if it were of greater vertical thickness it would stand fast, and resist the hydrostatic and progressive action of waves, not surpassing twenty feet in height.*

Breakwaters are, however, occasionally subject to augmented vio-

* Corroborative of this calculation, we find it stated in Lyell's Principles of Geology, that "on the Isle of Stenness, in the winter of 1802, a tabular mass of stone, eight and one-sixth feet by seven feet, by five and one-sixth feet in depth, was dislodged from its bed, (by the sea,) and removed to a distance of from eighty to ninety feet."

This quotation shows clearly enough that a depth of *more than five and one-sixth feet of stone* is necessary to withstand the action of waves.

A similar circumstance is stated in the public prints to have occurred in a severe storm recently, upon the coast of Massachusetts, near the Boon Island Lighthouse, where "a huge rock twenty-three feet long, sixteen feet wide, and six feet thick," which weighed probably 170 tons, was moved by the waves a considerable distance *up an inclined surface;* evincing there *that a vertical depth of six feet of solid stone* did not possess sufficient stability to resist the force of the sea.

How much more accurately than the moderns, the ancients appreciated the powerful action of waves against sea works, may be inferred by the following paragraph, quoted from Josephus, by Godwin, in the Trans. Instit. Brit. Archts., 1835–6.

"In order to form a port between Dora and Joppa, Herod, in the fifteenth year of his reign, ordered mighty stones to be cast into the sea at twenty fathoms water, to prepare a foundation; the greater number of them fifty feet in length, nine feet deep, and ten feet wide, and some were even larger than these."

Stone of these prodigious dimensions would be very likely to maintain their places in ordinary storms; and their magnitude is in striking contrast to the comparatively small materials used in modern Breakwaters, which, as a necessary consequence, *require incessant repairs.*

lence, from the assault of waves during storms, *owing to the partial removal of atmospheric pressure;* a fact which has recently been observed by James Walker, Esq., F. R. S. &c., President of the British Institution of Civil Engineers, and which was mentioned by him at a recent meeting of that Institute, (as reported in the Civil Engineer and Architects' Journal for September 1841,) in the following words: "At the Plymouth Breakwater, during the great storm in the month of February 1838, several of the largest granite blocks, weighing from three to eight tons each, composing the surface or pavement of the Breakwater, which, although squared and dovetailed into the structure, and embedded in excellent cement to the extent of their whole depth, and thus forming a solid mass, were torn from their positions, and projected over the Breakwater into the Sound."

"Mr. Walker attributed this to the hydrostatic pressure exerted beneath the stones, at the moment when the atmospheric pressure above had been disturbed by the masses of water suddenly and rapidly thrown upon the surface of the Breakwater; blocks of stone were thus often carried to a great distance, not so much by the waves lifting them as by the vacuum created above by the motion of the water, which exerted at the same time its full pressure from below."

And as additional evidence that the formation of a partial vacuum is sometimes a consequence of the envelopment of sea works by high waves, Mr. Walker further stated, "that during a storm in the year 1840, the sea door of the Eddystone Light-house was forced outwards, and its strong iron bolts and hinges broken by the atmospheric pressure from within. In this instance he conceived that the sweep of the vast body of water in motion round the light-house had created a partial and momentary, though effectual vacuum, and thus enabled the atmospheric pressure within the building to act upon the only yielding part of the structure."

As both the above remarkable instances came professionally under the notice of Mr. Walker, we are bound to place the utmost reliance upon the inferences derivable from his statements; and they indicate conclusively that no lateral connexion by dovetails, or otherwise, will compensate for a want of depth of solid stone; but that we must rely for stability in the coping of sea works, chiefly upon the weight of a large mass of materials, *so connected as to gravitate as one body;* we must oppose pressure by weight, and counteract by gravity the action of forces resulting from a disturbed equilibrium.

The pressure of the atmosphere is about the same per superficial foot as would be produced by the gravity of 11½ feet depth of stone weighing 175 lbs. per cubic foot; therefore, if Breakwaters

were liable to be assailed by waves but twenty feet high,* at the same time that the atmospheric pressure *was wholly removed*, their summits would require coping with a depth of stone wrought into a solid mass, equal to $11\frac{1}{2} + 7\frac{1}{2}$, or 19 feet, measured vertically.

In the nature of things, however, we cannot suppose that *the whole pressure* of the atmosphere would ever be removed from any point of the summit of a Breakwater whilst a wave of the maximum height was acting beneath; and though this is very much a matter of conjecture, we may probably infer that under no circumstances would more than two-thirds of the atmospheric pressure be removed from any point; this would be countervailed by a depth of eight feet of stone weighing 175 lbs. to the cubic foot, and as we have shown that a depth of near seven and a half feet is necessary to withstand the hydrostatic pressure of a twenty feet wave, we may finally infer that *the summits of Breakwaters should never consist of less than fifteen feet average depth of stone firmly bound into a solid mass, by clamps, dowels, and cement, so as to gravitate as one body.*†

The fact that continual repairs are rendered necessary, by the blowing up and sweeping away of portions of the pavements of existing

* The maximum height attained by the waves of the most violent storms, at the sites of Breakwaters, is such an important element in forming the plan of the work, that it ought always to be ascertained experimentally, (which would not be difficult,) by attaching a machine upon the principle of a self-registering tide gauge, to a pile well driven at the site, and properly braced against the sea.

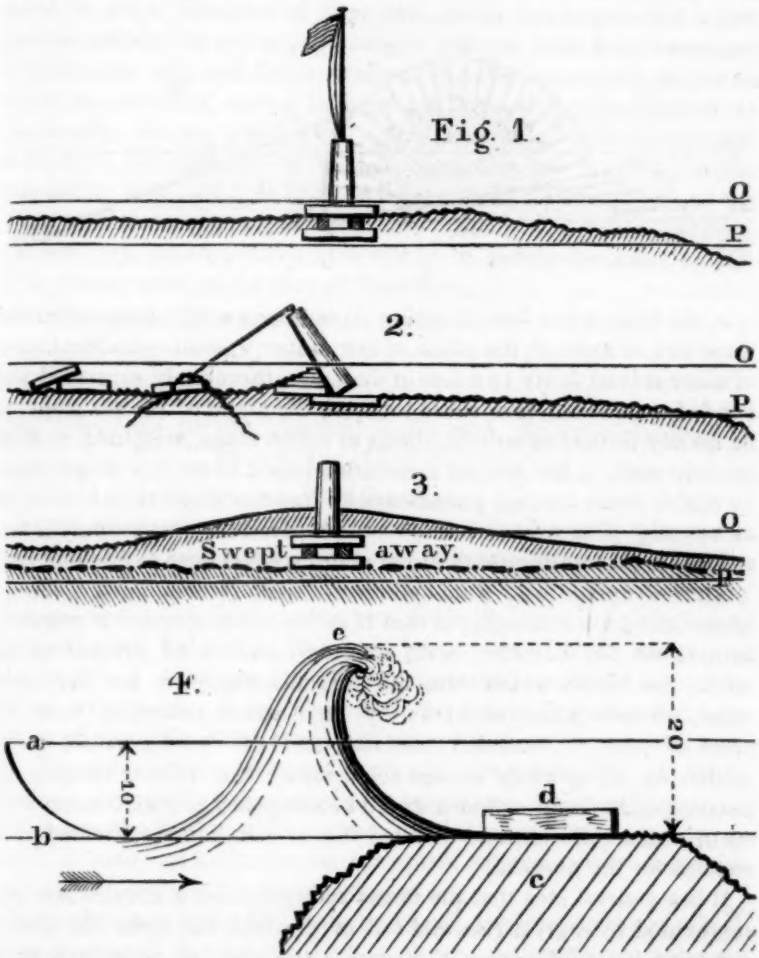
† This principle of constructing sea works, was adopted in Rudyerd's Light-house, built upon the Eddystone, in 1709, and which, after successfully withstanding the storms of half a century, was destroyed by fire in 1759; regarding it, Smeaton states that Rudyerd "judiciously laid hold of the great principle of engineering," that "*weight is the most naturally and effectually resisted by weight*," and accordingly formed his light-house, near its foundation, *solid*, and mainly of stone, for such a height as he conceived would enable the gravity of the mass to resist the upward hydrostatic pressure of the waves, in case the water insinuated itself beneath the building.

This idea was not lost upon the able and sagacious Smeaton, who, in erecting the famous stone light-house which succeeded Rudyerd's, built the first thirty feet high from the foundation, *solid*, and so proportioned the walls and lantern above the fundamental solid that if their mass were reduced to a cylindrical shape it would add another solid column of about twenty feet in height; so that in opposing the action of the sea, the Eddystone Light-house is equivalent to a solid column of stone fifty feet in altitude.

Now from the above reasoning, $50 \times 2\ 7\text{-}10$, or 135 feet, is the altitude of the wave, whose upward hydrostatic action this building is, by its gravity alone, competent to resist; and as the atmospheric pressure is never removed from its summit, whilst the utmost altitude of the jet of water which is sometimes thrown over the lantern is short of 100 feet, its superabundant stability must be manifest.

The courses of this celebrated construction being dovetailed and joggled together, so as to prevent movement laterally; as long as its materials are proof against decay, the immutable laws of gravitation will retain it in position, and enable it to defy, as it has for eighty-two years defied, the utmost force of the Atlantic storms; unless, indeed, it should be assaulted by waves more than 135 feet high, which is not within the range of probability.

Breakwaters, during violent storms, strongly sustains the views taken in this paper, and shows but too clearly, that the mass of stone usually combined upon their summits, is deficient in the requisite stability.



The form in which the stone ought to be laid and connected together, should (the writer believes,) be that of a semi-cylinder, the axis lengthwise of the work, and the base laid upon such an inclination seaward as may counteract sliding, and prevent the possibility of its overturning upon the harbour angle, for we know that on a level plane, one half the amount of force will overturn a body which is necessary to lift it.

In the case, then, of a Breakwater similarly situated to that of the Delaware, stone weighing 175 lbs. to the cubic foot, and exposed to the assault of waves not exceeding twenty feet high, it would seem that the section shown in the following Figure 5, would be a proper one.

5.

a, the high water line of spring tides, above which storm tides rise three feet or more; *b*, the plane of low water; *c*, semi-cylindrical mass of stone at least thirty two feet in diameter, thoroughly cemented and bonded together; *d*, fore shore securing the angle of the sea slope, to be mainly formed of cubical blocks of rough stone, weighing at least ten tons each; *e*, the general foundation raised to the low water plane by rubble stone thrown promiscuously into the water from the decks of vessels;* *f*, cemented foundation prepared for the semi-cylinder, and having a top slope seaward of about six feet base to one foot rise.

The advantage of a semi-cylindrical solid (which must average fifteen feet deep vertically) is that if in the construction it is properly bonded on the diameter, with thorough courses of dressed stone, whilst the blocks which form the curved surface are cut like *arch stone*, no one stone could be by any means extracted from its place if properly doweled laterally, and the whole would resist motion *by its gravity as one solid mass;* the interior backing or hearting of the semi-cylinder would be composed of rubble stone well set in cement mortar, and grouted full in low courses, divided into sections for the purpose.

It is a general idea that the forces acting against a Breakwater are augmented by a great rise and fall of the tide, but from the above reasoning it would appear that such a rise and fall as will allow a wave of the maximum height of twenty feet to exert its greatest energy; or a difference of ten feet between the top water of storm tides and the low water plane, (as exists at the Delaware Breakwater,) *will enable such waves to act with as much power upon sea works as any other variation of tidal surface,* and hence a greater rise and

* Experience at the Delaware Breakwater proved that by this process alone a rough stone work could be brought up with precision to a plane of two feet under the high water of neap tides.

fall than ten feet will not increase, whilst a less one would certainly diminish, the effects of the assailing waves.

The section of the Delaware Breakwater, as planned by the Commissioners appointed by the President of the United States, in 1829, under the act of Congress of May 24th, 1824, was trapezoidal in its general outline, the sea slope having a base of 105½ feet to a height of thirty-nine feet, and being profiled after the curvilinear figure to which the waves of storms had reduced that of the Breakwater at Cherbourg; the top was fixed at twenty-two feet,* and the internal or harbour slope at one to one, or thirty-nine feet base, the entire base being 166¾ feet to a height of thirty-nine feet; the base of the section which we have proposed as sufficient for a similar work, is 160 feet, and the transverse area would be nearly the same as that of the Breakwater in the Bay of Delaware.

Philadelphia, Nov. 1st, 1841.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Cast Iron Rail for the Hiwassee Railroad.† *Designed by* JOHN C. TRAUTWINE, *Civil Engineer.*

TO THE COMMITTEE ON PUBLICATION.

GENTLEMEN.—I send you a drawing of a rail which I conceive to possess some advantages over those hitherto employed, and which I shall introduce upon the railroad now under my charge. The great distance of our line from the nearest available shipping port, would have increased the cost of European iron to so serious an extent that our Board of Directors resolved to manufacture their own rails. About $110 per ton would have been the cost of English rolled rails, delivered along the line; nor could we obtain any lower bids from our Tennessee iron masters, although advertisements were published for some time, calling upon them for proposals. The principal cause of this was the limited scale of their establishments, which would not admit of their embarking in an enterprize so much more extensive than any of them had been accustomed to.

In furtherance of the object of the Board, the President and myself were deputized to visit the East, with instructions to procure such information, machinery, and workmen, as were essential for the manufacture of our iron, in every department, from the ore to the finished rail.

* With the design of increasing it to thirty feet if subsequently found necessary.

† This road runs from Knoxville, in East Tennessee, to the dividing line between the States of Tennessee and Georgia, where it unites with other lines now under construction, extending to Charleston and Savannah. Its length is 94½ miles.

The result of our investigations was a firm conviction on the part of both, that we could, by the use of coke, make our rails at about $ 60 per ton, or about one-half the price at which we could import them from England.

Having accomplished the object of our mission, the preliminary preparations for erecting the smelting furnaces, and rolling mill, were entered upon; but before much progress had been made in them, I had become so fully convinced of the efficiency and economy of *cast-iron for rails*, that I submitted to the Board a paper, recommending the abandonment of the rolling mill, and the substitution of a cast rail, of the accompanying design, for the rolled bridge rail, which I had first advocated.

My advice was adopted, and a corresponding change made in our plan of operations. Among other things, we decided to use *charcoal* instead of *coke*,* as producing iron of a superior quality for a *cast* rail.

In designing this rail, I availed myself of the results which have, of late years, been elicited from experiments made in both England and the United States, with a view of determining the strongest form of a cast iron beam.

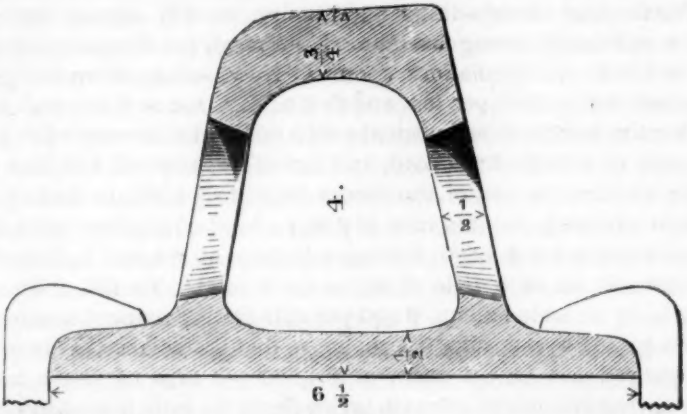
The surprizing discrepancy between these experiments, and the previously received theories, first awakened in me the hope that an effective cast rail might be made of a much less weight than was generally supposed; and although the nature of a rail, (which requires some modifications involving a departure from the strongest form of beam attainable by a given weight of metal,) does not admit of an application of the newly discovered properties of cast iron to their fullest extent, still I suspect I have made a nearer approximation of them than has hitherto been attained. The cases of a rail, and of a girder, are to a great degree analogous; and I have endeavoured to reconcile them so far as their respective functions admitted.

The first point clearly demonstrated, in my opinion, is the necessity of removing as much metal as possible from the vicinity of the neutral axis, and transferring it to the bottom rib, or base of the rail. With this view I introduced the openings in the sides of my rail, (see drawing;) and rejecting the use of the chair, *which contributes*

* This change was made at the suggestion of Mr. William Firmstone, now of Pottsville, Pennsylvania, who visited Tennessee for the purpose of designing our furnaces. I introduce his name that I may have an opportunity of expressing the entire satisfaction with which his skill, his readiness to impart information, and his urbane demeanour, impressed the Board of Directors and myself. I trust that his valuable services may meet with constant requisition.

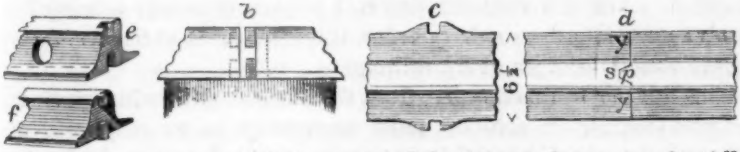
nothing to its strength, I employed both in forming a continuous bottom rib, extending entirely across the rail.

Transverse section. Half size.



Side View.

Details.



By this arrangement of the metal, I doubt not that a *much stiffer* rail can be made with a given weight of cast iron than of rolled, for the latter does not admit of this modification. Indeed the facility with which the most advantageous form, as deduced from theory, can be imparted to cast iron, constitutes an essential argument in deciding between the comparative merits of it and rolled iron.

Now a very important question is to be considered, viz: can we make a cast iron rail of sufficient strength to resist the accidental percussions to which it must necessarily be subjected occasionally, without the use of so much metal as to raise its cost to that of rolled iron. The answer to this question, of course involves the comparative cost of rolled and cast iron; and in endeavouring to solve it, I shall assume prices, which experience has shown may be safely depended on. Of course, I allude to prices in the United States, and also to the *manufacturing* prices, exclusive of the profits of the iron master; for I am willing to hope that other railroad companies besides ours, may find

it to their interest to make their own rails. Where ore and fuel are easily attainable, there can, in my opinion, be no doubt as to the expediency of their so doing.

For the sake of expediting our inquiry, we will assume that my rail is sufficiently strong for railroad purposes, (as I hope to show it is,) and base our calculations upon it. Now, setting down the price of rolled iron at $ 60 per ton, and that of cast iron at $ 30; and supposing the weight of an efficient rolled rail to be seventy-two* tons per mile of a single track road, and that of the cast rail 110 tons per mile; we have the cost of the former equal to $ 4,320, or adding the weight of chairs, (say ten tons at $ 30,) a total of $ 4,620; while that of the latter is but $ 3,300; leaving a balance of $ 1,320 in favour of the cast rail, on each mile of single track road. To this difference may fairly be added about $ 200 per mile for the reduced number of spikes gained by rejecting the chairs, so that the balance in favour of the cast rail may be set down at $ 1,500 per mile of single track. Any saving that might accrue in laying down the rails, from dispensing with the labour of fixing the chairs, would be counterbalanced by the increased expense of handling the great weight of the cast rail, and of course should not be taken into consideration. The question of *cost* being therefore settled in favour of cast iron, it remains to inquire whether our assumption of the efficiency of my rail was well founded. And this consideration is, I believe, generally admitted to resolve itself into the single question of its resistance to the *accidental shocks* which occur on every railroad.

The answer to this inquiry, from the limited data with which we are provided for its solution, must necessarily be an empirical one. From all the experiments I have seen recorded, I do not doubt that this rail will bear, with *perfect safety*, a *quiescent* load of at least *ten tons to a wheel;* and that one of *double* that weight would be required to *break it.* Now, it will, in all probability, never be found expedient, in practice, to place more than three tons on a wheel, not even on the driving wheel of a locomotive, for there are considerations which, in my opinion, render it preferable to increase the number of driving wheels, instead of placing more than three tons on any single one. Thus we see that the rail will bear, with *perfect safety*, a *quiescent load* more than three times as great as it will be likely ever to be subjected to, and more than six times as great as would be required to break it. The test load which I intend to apply to my rails, before laying them on the road, will be fifteen tons to a wheel; and should it happen, (as I cannot anticipate,) that that load

* This is the weight of the rolled bridge rail, which I had adopted before the substitution of the cast rail.

is too great, I shall, instead of diminishing it, increase the strength of the rail.

But it is the *percussive*, and not the *quiescent* force, against which we must guard. There can be no doubt, I presume, in the mind of any Engineer, that if the rail were required to bear only the quiescent load referred to, the case would admit of no dispute.

To attempt, (with the limited data we now possess,) to *calculate* what this force would be, in any particular instance, might serve as an amusement for abstract mathematicians, but would be attended with results quite as deceptive as their researches into the equilibrium of arches, and many other subjects, in which, for want of *experimental* data, most erroneous assumptions were employed as the basis of their investigations. I hesitate not to say, that with our present data, the query is not susceptible of solution.

"Give me a *fact*, and I'll make you a *theory*," wisely said a certain professor; and in pursuance of his idea, we shall merely present to the reader the following fact. It may be objected that this is a very unsatisfactory mode of determining the point in question. This I admit; and my apology for submitting it, is simply that I know of none more satisfactory.

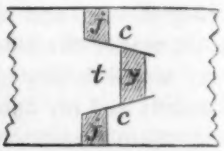
Mr. Strickland, in his reports, (see Strickland's Reports, page 29,) remarks that the best cast rail he saw in England was the elliptical rail used on the Sunderland and Hetton road; on which a traffic of 1,000 tons per day was carried. Now, in comparing these rails with mine, *three very essential* points of difference will be perceived, all favouring the latter, viz: 1st. Mine contains fifty per cent. more metal than the English rail; the latter weighing, without its chairs, seventy-two tons per mile, single track, and mine 110 tons.* 2nd. The form of mine is much better adapted to securing the maximum of strength with the minimum of material. 3rd. The clear bearing of my rail is but *one-half* that of the English. Now I conceive, that supposing the two rails, with their respective weights, to be of the same shape, and to differ in no other respect, mine should even then bear one-half more than the other, making their comparative strengths as one to one and a half. But experiment has shown, that with the proportionate weight of the two rails, the difference of *form* gives a comparative strength of *at least* one to two in favour of mine. This brings up the former proportion to, as one to three. But again the same experiments have shown that the resistances of the rails will be inversely about as their length; this fact still further augments the proportionate difference to, as one to six. In other words, I conceive my rail to be six times as strong as the Hetton rail, pronounced by

*Of 2240 lbs.

Mr. Strickland to be the best *cast* rail he saw in England. It is true, that at the time he wrote his reports, railroads were in their infancy, locomotives were lighter, and their speed less than at the present day, but still no subsequent experience has indicated a necessity for making the cast rail more than six times as strong as those in use at that time.

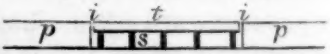
In order to guard as far as practicable, against unusual shocks, I have adopted a form of joint for my rail, which, in connexion with the use of piles firmly driven, will, I suspect, effectually prevent any displacement, and secure a perfectly smooth and unyielding surface for the cars to travel over. This joint is exhibited in figs. *b*, *d*, *e*, and it will be seen, on examination, that it secures the ends of any two rails from either *horizontal* or *vertical* displacement, with reference to each other.

I will here mention an advantage of the greatest importance, attending the use of a tongue, which, for what I am aware to the contrary, may be generally known, but which I do not recollect ever to have seen recorded, viz., *that it prevents the wheels from falling into the joints between the rails*, no matter how open they may be. Thus the tongue *t* prevents the wheels from settling into the parts *i i*, of the joint, and the sides *c c*, of the mortise, prevent them from settling into the part *y*; so that if we can only prevent *vertical* displacement at the joinings of the rails, the opening of the joints by contraction and expansion becomes a matter of no importance.



After my rails are spiked down I intend to dress off the joints perfectly by filing, and I expect them afterwards to retain their adjustment. I shall, moreover, append, as a permanent attachment, a strong guard in front of each locomotive, which, by descending to within an inch of the rail, will throw from the track any casual obstruction that would give rise to a dangerous elevation of the wheels.

I have spoken of my intention to test all my rails before permitting them to be laid on the road. The apparatus which I shall use for this purpose is very simple, consisting merely of a loaded car, running on a few feet of permanent and very strong rails, *p p*, which are laid with a sufficient interval, *i i*, to allow of the introduction of the rail to be tested, *t*. The car loaded with fifteen tons to a wheel, is pushed from one permanent rail to the other, passing over *t*, in its transit. By means of this apparatus, I shall be able to ascertain whether my rail requires any modifications before final adoption. I hope too, to be able, before long, to institute a set of experiments on cast iron beams, more full than any hitherto tried.



My adoption of the general form of the bridge rail, instead of the T rail, will, I presume, require no arguments in its favour. Where *cast* iron is used, the question does not involve so much difficulty as in the case of rolled iron.

As the propriety of introducing *cast* iron for rails depends much, if not *essentially*, on the securing of a firm support for it, I intend to reject the common wooden superstructure of mud sills, cross ties, and longitudinal, or string pieces, respecting which I believe almost every engineer will unite with me in saying, that it is *impossible*, (although I do not admire that term,) to joint its several parts so perfectly as to prevent derangement. For this very unstable foundation I shall substitute stout piles, from twelve to eighteen inches in diameter, well *charred*, and driven into the graded surface at intervals of three feet from centre to centre, until their resistance to the ram denotes that all chance of future yielding is prevented. Their heads will be left but some three inches above ground. As the soil of all my embankments is a very firm gravely loam, well compacted in regular layers of but one foot in thickness, I might possibly omit the introduction of *cross ties*, until experience showed whether or not they were necessary. But it is my intention to insert *iron tie rods* believing that they will be found advisable. In cases where the embankments of a road have not been carried up in such a manner as to prevent settlement, I would prefer to drive the piles through to, (or even *into*,) the original surface; for although I look upon piles as being the best of supports for rails, *where they are driven into a firm foundation*, yet I consider them, perhaps, the *worst* of all, when that point is disregarded. I shall resort to *charring* in preference to *kyanizing*, on the score of trouble and expense. Indeed I am not certain, but it is nearly as effective a remedy for rot, especially under ground. The *head of the piles* might, if appearances should indicate its utility, be washed occasionally with a solution of corrosive sublimate, or some other preservative. I do not apprehend that the friction from driving will rub off the charred surface to an injurious extent.

Piles for railroads, will, I doubt not, soon supersede all other foundations. In addition to their perfect efficiency, when properly employed, they form a *cheap* road; cheaper than the ordinary methods of construction. A road of prepared timber, properly driven, securely tied transversely, and carrying a heavy cast rail, will, I venture to say, cost greatly less than many of the roads already constructed in this country, *and be kept in repair at comparatively a very trifling expense. Indeed, until a perfectly unyielding support is found for the rail, and entire inflexibility attained in the rail itself, I conceive railroads to be in their infancy.* Nor do I at all yield assent

to the current opinion, that to attain these desiderata, will be attended by an enormous increase of expense. ***I maintain that railroads have already reached their maximum of cost; and indeed that they have exceeded what is necessary to form a perfect railroad.*** Perhaps hollow *cast iron pipes* might in some instances be substituted for *wooden piles.* They would be far more expensive, but still make a cheaper road than some of the plans most in vogue at the present time. It will not be, until we construct railroads on these principles, getting rid of the annual repairs of *way*, and to a great degree of *cars*, that the railroad system will develope itself in all its glory; and securely bid defiance to the rivalry of canals, steamboats, and turnpikes. The attainment of a smooth, unyielding surface, I consider a matter of paramount importance, even to that of low grades.*

J. C. T.

* Having had no experience in the use of piles *for supporting rails*, and being unwilling to incur any risk of failure by substituting a somewhat novel mode of construction, for one whose merits, and demerits have been fully tested in practice; and moreover, not having the pleasure of a personal acquaintance with any of the Civil Engineers who have been engaged in the construction of *piled* roads in the Eastern States, I gladly avail myself of the medium of this Journal, to solicit from such of them as may be willing to communicate the result of their experience, answers to the following queries. And let me here suggest, that, since the design of establishing a Society of Civil Engineers in the United States has failed, perhaps the principal object of such an institution would be secured, by the general adoption of this mode of seeking information through the Journal.

Query 1st.—Is there any danger that the vibration of the soil, from the passage of trains, may loosen the earth in contact with the piles, so as to allow of the admission of water, or of lateral displacement? especially in curves, and near the edges of embankments?

2nd.—What length of pile has experience proved to be sufficient for the prevention of lateral yielding, in the above cases, (supposing the use of 3×8 cross ties, or of iron rods;) and also in cuts, or a firm natural surface?

3rd.—Are there any roads, or *detached portions* of any road, on which the piles *have not been driven through the embankments entirely down to the natural surface;* and if so, how have they answered.

4th.—Does the security of a piled road against *vertical* displacement fully compensate for its *greater tendency to lateral* motion?

5th.—What is the comparative *annual expense of repairs*, between a piled road and one of the ordinary construction of mud sills, cross ties and strings?

Any replies to these queries, either through the medium of the Journal, or by private letter, will be thankfully received. I should prefer the latter on account of time. Permission to publish might be granted in the letter, and if so I will hand it over to the Actuary of the Franklin Institute. It will afford me much pleasure to reciprocate such favours whenever the opportunity offers.

Practical & Theoretical Mechanics & Chemistry.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Observations on Blast Furnaces for Iron Smelting. By S. W. Roberts, Civil Engineer. No. 1.

Old Cattawissa Furnace, Columbia county, Pennsylvania. W. C. Leavensworth, lessee. Observations made October 13th, 1841 Working with charcoal and a cold blast.

Stack twenty-eight feet high; lined with slate. Boshes seven feet four inches, and tunnel head sixteen inches in diameter. Hearth stones siliceous conglomerate. Water power from Furnace Run.

Width of trunk fourteen inches, cross section of flowing water half a superficial foot, flows seventy feet at the rate of one foot per second. Falls twenty-five feet. Water equals half a cubic foot per second, or thirty cubic feet per minute. 62½ lbs. × 30 = 1875 lbs., falling per minute, multiplied by twenty-five feet fall = 46,875 lbs. falling one foot per minute; being, without deduction for loss, about one and a half horse power of Watt's steam standard. And deducing one-third, according to Smeaton's rule, shows that the power exerted does not exceed *one* horse power, which is very small when compared with the iron made. Water wheel is thirty-two feet in diameter, or one hundred feet in circumference, and turns once in eighty seconds, or at the rate of one and a quarter feet per second. The water is applied twenty-five feet above the bottom of the wheel, which is old and leaky.

There are two single-acting, wooden, blowing-tubs, each six feet five inches in diameter, three feet ten inches stroke; giving six tubs full of air for each revolution of wheel. Area of a tub 32.37 feet; stroke 3.83 feet; contents 124 cubic feet × 6 = 744 cubic feet of air blown per revolution of wheel in eighty seconds; equal *five hundred and fifty-eight cubic feet of cold air per minute*—blown through a single tuyere about two and three-fourth inches in diameter.

Last week the furnace made eighteen tons of grey pig-iron, being 40,320 lbs. of iron. In the week the furnace took one hundred and sixteen charges, called "half-charges." Each half-charge had nineteen boxes of raw ore. (Bloomsburg calcareous ore, broken to the size of Macadamized stone.) Each box contained thirty-five pounds of ore. 35 × 19 = 665 lbs. ore × 116 half-charges = 77,140 lbs. ore per week. Each half-charge had one box of forge cinder weighing thirty-five pounds × 116 = 4060 lbs. cinder. 4060 + 77,140 = 81,200 lbs. of ore and cinder, which yielded 40,320 lbs. of iron—being very nearly

fifty per cent. Forty-five pounds of broken limestone to a half-charge $45 \times 116 = 5220$ lbs. limestone per week.

Seven baskets of good charcoal to a half-charge, averaging three and a quarter bushels each, $7 \times 3\frac{1}{4} = 22.75$ bushels $\times 116 = 2639$ bushels charcoal per week, which, divided by eighteen tons of iron made, gives *one hundred and forty-seven bushels of charcoal per ton of iron.*

Eighty-one thousand two hundred pounds of ore and cinder, divided by eighteen, will give four thousand five hundred and eleven pounds, or *two tons and thirty-one pounds of ore, &c. per ton of iron.*

Five thousand two hundred and twenty pounds of limestone divided by eighteen, will give *two hundred and ninety pounds of limestone per ton of iron.*

Estimating twenty pounds of carbon in a bushel of charcoal; $2639 \times 20 = 52{,}780$ lbs. of carbon per week; and five hundred and fifty-eight cubic feet of air per minute $\times 10{,}080$ minutes in a week $= 5{,}624{,}640$ cubic feet of air per week, which divided by fifty-two thousand seven hundred and eighty pounds of carbon, will give *one hundred and six cubic feet of air blown per pound of carbon consumed.*

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On White Lead. *By* James C. Booth.

The large quantities of white lead employed as a pigment by our painters, the number of patents which have been issued abroad, proving its extensive employment, the large amount of capital invested in its manufacture, bespeak a material of no ordinary importance, and lead us to enquire whether the processes by which it is produced may not be improved relatively to economy and convenience. Undoubtedly one method by which this end may be attained is by a thorough knowledge of the chemical principles which are involved in its production, ere we can take a higher step in the application of chemistry to its improvement; and it is to this point the following remarks will be directed, by investigating the theory of the processes which are now pursued.

There are three principal modifications of the processes for producing white lead, which will include all the patents that have been granted, subject of course to such variations as secure the privileges of numerous patentees. They are those in which the formation of white lead is in whole, or in part, induced by atmospheric agency, those operating by single, and lastly those by double elective affinity.

I. *Triturating Processes.*—1. The earliest account which I have

been enabled to procure of the manufacture of white lead by the action of atmospheric agents alone, or in chief part, will be found in this Journal, vol. i, 3rd series, p. 158, from which it appears that G. F. Hagner obtained a patent for such a process in 1817. Finely granulated metallic lead was made to revolve in cylinders with water and a portion of vinegar, the air having access; by which means it was converted into a white substance, a mixture of carbonate and hydrate, as we shall find below. When used as a pigment, this white lead was very liable to become yellow, in consequence of which the process was so varied as to fall more evidently under those dependant on single elective affinity. The manufacturers performed upwards of two thousand experiments in the course of five years, and produced an article of such a quality that in 1826 they obtained a premium for it from the Franklin Institute.

2. In 1818, J. Richards obtained a patent for a process on similar principles, excepting that he appears to have employed only lead, air and water, (Jour. Frank. Inst. vol. xxvi, pp. 125, 175.) The white lead was deficient in color and body, as may be seen in the Technical Collection of the Franklin Institute.

3. In the Lond. Jour. of Arts & Science, vol. v, 1835, may be found a patent of Torassa, Muston and Wood, in which granulated lead was shaken in a moistened state on trays and the comminuted gray mass exposed to the air until a white lead was formed. From the date of the patent, 1833, it is very possible that the first ideas of the process were derived from G. F. Hagner, while the latter was in England in 1817–18, (Jour. Frank. Inst., vol i, 3rd series, p. 159.) "It is said that upwards of £ 100,000 have been expended at Chelsea, by a joint stock company—for executing this most operose and defective process." (Ure's Dict., p. 1300.)

4. Notwithstanding the ill success of these processes, we find another patent, (Jour. Frank. Inst., vol. xxvi, p. 119,) taken out by Homer Holland, in which the same mode of making the white oxide, &c., is claimed by the patentee, excepting that to make the carbonate, he introduces a portion of carbonate of soda into the water. In an amended patent (1838) he claims the use of any alcaline salt or substitute, whose elements consists of oxygen, carbon and hydrogen instead of alcaline carbonates.

5. The Jour. Frank. Inst., vol. xxvi, p. 123, presents another patent by Smith Gardner for making white lead by attrition, with this variation, that the operation is conducted in close vessels into which carbonic acid and air are driven during the attrition, thereby presenting them, says the patentee, "to the suboxide of lead in its nascent state.

"By introducing a very small portion of vapour of vinegar" with the gases, a superior article is at once obtained perfectly free from color.

Before passing to a consideration of the principles involved in the above processes, we may be allowed to remark, 1st. That by a comparison of the dates of the 2nd and 4th patents, it is clear that it would be very advisable for patentees to examine previous patents on the same subject, before they lay open their patent to legal attacks and flaws. 2nd. That by comparing the 3rd patent with the first two, it is evident that a vast amount of capital might be saved by first ascertaining what results others have obtained before we enter the same field of research. 3rd. That the 4th patent shows that to give a clear scientific view of a chemical process, something more is requisite than a superficial knowledge of the science, for in the patentee's first project, he calls the compound produced by attrition of lead a suboxide, and in the amended project he is constrained "to disclaim the opinion, that plumbic pulp, under any circumstances, can be considered a definite compound, and much less an oxide; but that it is a compound of lead, into which the elements, hydrogen, carbon and nitrogen, enter, as well as oxygen." Neither of these views being correct, it would have been better to have avoided such theoretic expressions altogether.

Bonsdorf* exposed a clear surface of lead to moist air which soon coated it with suboxide. A similar piece of lead laid in pure water containing air soon began to form a cloud of hydrated oxide of lead, which dissolved in the water. The smallest quantity of foreign matter, particularly of a saline nature, except nitrates, prevents this action; and so delicate is the test that Bonsdorf thinks it may be employed to try the purity of water, by throwing filings of metallic lead on the surface and observing a few minutes whether the small cloud of hydrate appears; which only occurs when the water is pure. This fact shows why the first project of the 4th patent could not be successful, by introducing a carbonated alcali into the water in which metallic lead was triturated to form an oxide and from that a carbonate, even if there were no other grounds to repudiate such a process. So far from accelerating it must have retarded the operation.

Bonsdorf found still farther that if, instead of permitting the lead to form a hydrate by resting in the water, it were put into a flask and the latter closed up and shaken, suboxide alone formed on the surface. He explains the fact on the theory, that when the lead is at rest, electric currents are formed between the metal and its oxidized points, which determine a higher oxidation, even as far as red lead, according to his observations, while by shaking, the currents are disturbed, and the whole surface of the lead becomes suboxidized, which prevents further oxidation even if left at rest. Hence it follows

* Berzelius Jahresbericht, 1837.

that the lead must first be uniformly suboxidized by trituration, and as it passes into a higher state of oxidation takes up water and carbonic acid, but in the 3rd patent a portion of the oxide and carbonate evidently formed after exposure to the atmosphere. It is probable that in all such cases where carbonic acid is not artificially used, a certain quantity of that acid will be absorbed by the oxides upon exposure to the air subsequent to attrition. The comminuted lead when taken from the trays, where the lead was only moistened, has the dark gray color of suboxide, and first assumes its white appearance by exposure to the atmosphere.

The same chemist exposed a lead plate to moist air until the whole surface was suboxidized, then removed it from a portion of the surface and covered this with water, at which place a vegetation was formed, which he found to consist of one atom of carbonate, and one atom of hydrate of lead. It is therefore a simple hydrocarbonate of lead. This is, in all probability, the substance that is formed in the first four patents, where carbonic acid was not artificially introduced; for where the quantity of this acid is as small as that contained in the atmosphere, and, where the tendency of the lead is also to form a hydrate, it is not probable that this acid should in its very diffused state usurp the place of much of the hydrate.

When vinegar is introduced in these processes, another operation takes place, which induces the more rapid formation of an oxide of lead, preventing at the same time the formation of as much hydrate, and the acetate which forms being simultaneously decomposed by carbonic acid, the vinegar as rapidly passes to another portion of oxide.

In Bonsdorf's experiments the hydrocarbonate was tried as a pigment and found to possess little body, a circumstance which will probably hold good with nearly all white lead made by the above processes, excepting the last, and the modified operations of the first, patent. In the fifth patent carbonic acid is forced in with atmospheric air and probably acts in part catalytically by inducing the formation of oxide, and in part by uniting with the oxide "in its nascent state," and thereby preventing the formation of as large a quantity of hydrate. It is said moreover that the white lead thus obtained is equal to that manufactured by the older processes, (Jour. Frank. Inst., vol. xxvi, p. 125,) but I question whether it will be found to contain a requisite quantity of carbonic acid to prevent its liability to become yellow. It remains to be seen, however, whether by any one of these processes, in which trituration of metallic lead is the chief point, the mingled hydrate and carbonate of lead contains a sufficient amount of carbo-

nate to prevent its becoming yellow by employment as a pigment; for that was the chief difficulty experienced by the first patent, and probably will be an objection to all the others; and it will be shown below that the more highly carbonated the lead is, the less it is subject to this change. The economy of the process of attrition certainly demands attention, as well as the simple arrangements by which it may be effected, but then the question returns, whether the tendency to become yellow by exposure to the atmosphere, or of vapors, can be obviated by giving the highest dose of carbonic acid, partly by driving that gas through the apparatus, and partly by introducing another ingredient into the water employed. If this point be attained, the question may again be asked whether body can be given to the compound, and whether it can be thus made destitute of a crystaline structure, for in the experiments of Bonsdorf, given above, the vegetation evinced a strong tendency to crystalization, and it appears that the same objection is generally urged against white lead made by attrition, viz: it is deficient in body.

If the theory advanced in the fifth patent (Jour. Frank. Inst., vol. xxvi, p. 123) be correct, that the white lead formed by attrition, where carbonic acid is presented to oxide of lead in its nascent state, is possessed of body and a good color, then we may hope that the process of attrition may yet be productive of good results. It should not be forgotten, however, that in all these processes carbonic acid is really present and in considerable quantity, if we suppose a large amount of air to pass over the agitated lead, but then the quantity, relatively to the oxygen of the atmosphere is very small. I would suggest whether it would not be desirable to perform an experiment in a similar manner to the above, in which water may be omitted and due proportions of air and carbonic acid driven through an agitated apparatus containing simply moistened lead, either without or, perhaps better, with the aid of steam, or at a higher than the ordinary atmospheric temperatures.

II. *Processes more or less dependent on Single Elective Affinity.*—These processes all depend upon the decomposition of a subsalt of lead by carbonic acid. 1. Thènard made the first suggestion relative to the principle, and MM. Brechoz and Leseur, who arranged the contrivances for conducting the process, received a prize for their white lead. Neutral acetate of lead was digested with litharge forming a soluble subacetate, through which, diluted with water, was passed a stream of carbonic acid. Carbonate of lead precipitated and there remained a neutral acetate in solution, which being redigested with litharge, again formed a subsalt and was again precipitated as before. Thus the acetate of lead first employed was constantly used

in the operation, a small portion of new material being added each time to allow for accidental loss and waste. All subsequent patents based on a similar principle were derived from the above patent, which was carried out on a large scale by MM. Roard and Brechoz. At this day, a large portion of white lead used in France and Sweden, is similarly manufactured, and the process is also employed in Germany, England, and at one establishment in this country, in Brooklyn, New York. It is generally believed that the old processes for manufacturing white lead by using fermenting tan, &c., and that in which vinegar, air and carbonic acid are driven into chambers containing lead and vinegar, are governed by different principles, but it will be shown that they are essentially the same with those where carbonic acid is passed through a subsalt of lead.

A. Precipitating Processes.—2. It was stated above that G. F. Hagner obtained a patent in 1817 for manufacturing white lead by attrition, but that the quality of the material being inferior, the proprietors varied the apparatus and process in such a manner as to approach Thènard's method. For a more minute description of their plan, see Jour. Frank. Inst., vol. i, 3rd series, p. 158. They forced carbonic acid through a mixture of litharge, pulpy oxide produced by attrition, and vinegar, and their white lead was of such a quality as to receive a medal in 1826.

3. Button and Dyar took out a patent for making white lead, the specification of which will be found in Rep. Pat. Inv. vol. x, 1838, with a drawing illustrating the apparatus. They employed purified carbonic acid from the combustion of coke, which was passed through a mixture of litharge and nitrate of lead dissolved and suspended in water, and kept at the boiling point of water in a state of agitation by the issue of steam in the bottom of the decomposing vats. The carbonate as it formed was drawn up by a pump, suspended in water, and falling on a filter, where it remained, suffered the liquid to fall through into the first vat.

4. In the Jour. Frank. Inst., vol. xxv, p. 197, are remarks on the manufacture of white lead by Mr. Benson who is probably the same one engaged with Mr. Gossage in the manufacture, near Birmingham, England. According to their patent, they employ of vinegar $\frac{1}{300}$ of the weight of litharge, and add so much moisture to the latter that it merely "feels sensibly damp to the touch." Heated carbonic acid (from coke) is passed over this mixture in stone troughs, while the contents are powerfully stirrred up, (Ure's Dict.)

5. Cory's patent in Rep. Pat. Inv., vol. xii, 1839, employs carbonic acid derived from a lime-kiln, introducing it into a chamber, the upper part or ceiling of which is perforated with numerous small holes. A

solution of subacetate of lead is pumped up to the roof of the chamber and falls through the small holes like a shower, absorbing carbonic acid in its descent.

These are the principal variations in the precipitating method of Thènard; all are referable to the same theory, viz., the decomposition of a sub-salt of lead by carbonic acid. The last is evidently the same, excepting that the operation is inverted, and instead of passing carbonic acid through the solution, the latter drops through an atmosphere of the acid. The second is somewhat analogous to the fourth patent, excepting that the latter prescribes less moisture and employs heated carbonic acid. In both, the acid operates by forming carbonate of lead from a part of the oxide in the basic acetate, while the latter, becoming more neutral, is acted upon by the excess of litharge, forming again the basic acetate, which is again decomposed. The third patent employs a basic nitrate of lead, i. e. nitrate of lead and litharge, instead of an acetate, which, together with the boiling state of the solution, constitutes its difference from the others.

According to the observations of Robiquet, Pfaff, and others, the carbonate of lead obtained by precipitation with carbonic acid is a neutral salt, consisting of one atom each of acid and base, the only water present being hygroscopic. In the Bullet. d. Sciences, &c. en Neerlande, vol. i, p. 302, Mulder has shown that the white leads of commerce consist of two atoms of carbonate of lead and one atom of hydrate, but I do not know whether he experimented on white lead precipitated by carbonic acid, among the rest; the probability is that he did, for the process is evidently similar to the older method, in which a fermenting material is employed.

The carbonate of lead formed by these processes, whether similar or not in composition to the ordinary kinds, differs in one essential point, that it will not cover as well, and has less body; and Dr. Ure appears to have first pointed out the cause of this defect; for on examining it microscopically, he found it to consist of small crystaline particles, with a certain degree of translucency. White lead produced by the older methods is superior to it in these respects, which Mr. Benson, and I think justly, refers to "its never having departed from the solid state," and that the particles "have not been at liberty to arrange themselves symmetrically." In his patent, therefore, (fourth,) he employs a quantity of moisture just sufficient to determine the action of the carbonic acid. It is said that Messrs. Gossage and Benson produce forty tons of excellent white lead per week, (Ure's Dict.,)—La Societé d' Encouragement made a large number of experiments on the various kinds of white lead, and came to the conclusion that that produced by precipitation will cover as well as

the others, but requires more coatings, that it has a degree of translucency, but that it is whiter than that made by the older process.'' (Dict. de l' Industrie, &c., Tome iii, p. 164.) It may be that this defect of body may be remedied by violent agitation during the process of precipitation, which would disturb the crystalization. If so, the third patent should produce a dense material, and it is probable that the violent stirring in the fourth may have this effect in addition to its exposing a greater surface to the action of the carbonic acid. We shall dismiss the fifth patent with the remark that the extent of apparatus required is decidedly objectionable, and that it is inefficient, since the liquid must be pumped up several times, and suffered to fall in showers, before the decomposition is sufficiently effected.

There are several points deserving of notice, relative to this mode of manufacturing white lead. The quantity of litharge obtained in different processes of the arts is greater than the commercial demand for it, and as a reconversion of it into metallic lead is attended with a loss of more than one-sixteenth of its weight, it is desirable to find purposes to which it may be directly applied, unattended with loss. These processes for making white lead are of such a character, and hence, if the best quality of white lead cannot now be made by them, it is worth devoting time to their improvement. But, again, there is a much greater nicety in conducting these operations over the old methods, and there may be introduced into them a greater certainty in regard to the amounts of the several materials employed, circumstances which certainly impart some value to them considered with reference to the health and cleanliness of operatives, and to economy to the manufacturer. Of all the processes given above I should be inclined to prefer that of the fourth patent, as being most likely on theoretic grounds to produce the best result. Before closing this portion of our subject, we must make reference to the manufactory at Brooklyn, New York, the only one in this country, as far as my information extends, where Thènard's principle is successfully pursued. The sample of white lead from this establishment, offered at the exhibition of the Franklin Institute last Fall, was considered to be about equal to the others, and spoke well for the method, if it was made on this principle, for I understand they pursue both the older and the precipitating processes.

B. Older processes.—Among these we include the old Dutch method, where a fermenting material was employed, and that which substitutes a heated chamber for the fermenting beds. The oldest among these is probably that which originated in Holland, where rolled sheet lead is placed in earthen pots containing a small quantity of vinegar in the bottom, and these pots then buried in dung, which,

by its fermentation, produces both heat, steam, and carbonic acid. This method being that which is chiefly pursued in this country, we shall not enter into technical details respecting it. The English substitute fermenting tan for dung, otherwise the process is the same. The Kremser white is produced by a variation of the same process. It is conducted in different parts of Austria, particularly at Klagenfurth, in Carinthia, and the lead, which is very pure, is obtained from Bleiberg, in Carinthia. Sheets of lead are hung in small wooden troughs, in the bottom of which is poured mixtures, varying in different establishments, sometimes equal parts of wine lees and vinegar, &c. The troughs, to the number of ninety, more or less, are placed in a chamber, each one closed up, and the whole chamber heated by a furnace to about the temperature of 100° Fahrenheit. If the heat be too high, carbonic acid escapes, and less white lead is the result. It is generally conceded by the best judges that the best Carinthian white lead is superior to all other kinds.

Now if we suppose that twenty-three out of twenty-four hundred weight of lead are converted into white lead, then for these twenty-three hundred weight may be employed nearly 1300 lb. of vinegar, of such a strength that it would convert 128 lbs. of lead into neutral acetate. It is true that in different establishments the relative quantities of vinegar and lead vary, but still the variation is an immaterial point, for the former is rarely more than the fractional part of the lead employed; thus a pint, or a half pint of comparatively weak acid is used to three pounds of lead. It is therefore clearly evident that the former theory, that vinegar both yielded oxygen and carbonic acid, or either one, to form white lead, is either wholly without foundation, or else its service in this respect would produce but a very small part of the white lead, which is actually obtained; or suppose that a bed of 6,000 pots, of ten tier, and 600 in a tier, or layer, contained one pint of vinegar, and three pounds of lead in each, and that the pint of acid contained one ounce of *dry* acetic acid; the whole bed would then contain 18,000 lbs. of lead, and 6,000 oz. of dry acid. But this acid would consist of 2852.4 carbon, 2798.4 oxygen, and 349.2 hydrogen in ounces. Then the 2852.4 oz. of carbon, if converted into carbonic acid, would take up 3,015 lbs. of lead to form a carbonate, or about one-sixth of the metal contained in the bed, while the above amount of oxygen would only take up 2,268 lbs. of lead to make an oxide, or one-eighth of the amount of metal which is present. It follows clearly that the acetic acid is neither employed to yield oxygen for oxidizing, nor carbon for producing a carbonate, to any appreciable extent, and, moreover, it should not be forgotten that a much smaller quantity of vinegar will suffice to produce a car-

bonate than is specified above. The chief products arising from the fermentation of dung are carbonic acid, carbonate of ammonia and water, the second of which may be omitted, as it arises in small quantity from tan, which is employed with success in England. The heat of fermentation then will raise vapour of vinegar, carbonic acid and water; but there is another material of value present in this process, the atmosphere, notwithstanding experiments made in Europe,* which seemed to show that its presence deteriorated the colour of the white lead; for in all the ordinary processes it must be present, and in those which follow it has been shown by direct experiment to be essential to the formation of oxide. The moisture which is present appears to act chiefly by determining the action of the other substances, and not to be decomposed, for we have no evidence of its decomposition, and the changes which ensue to the lead can be satisfactorily explained without it. It may, however, be maintained that it assists in forming oxide, but in the subsequent experiments, air being found necessary, proves that the chief use of the latter is to oxidize the lead. We have shown above that in Bonsdorf's experiments the lead will oxidize in a moist atmosphere, and that the presence of carbonic acid tends to hasten the operation, with the production of a carbonate; acetic acid, then, by its more energetic action, will surely produce an acetate, and where its quantity is small, this will be a sub-salt. But there is carbonic acid also present, and the material must be moist enough to determine its action in decomposing the acetate; while the acetic acid, thus slowly disengaged, will act similarly on another portion of the metal, or its oxide. To this it may be objected, that at length there will be a neutral salt formed, which the carbonic acid cannot decompose. It is, however, shown that this acid will decom. pose even the neutral salt to a certain extent, when it is in solution. It is not, however, necessary to suppose this, for during the length of time required for the conversion of the lead, the whole of the vinegar might be evaporated without its being noticed by its odour above the bed to any appreciable extent, and as each successive portion of acetate is decomposed, a portion of the acid may thus be volatilized and escape into the atmosphere. Another explanation of this presently appears. That acetate of lead is thus formed is shown from the amount of it lost upon washing white lead, which is so great that it becomes a question with the manufacturer whether it might not be re-extracted as acetate, or better in some other form. It may be farther objected that if carbonic acid is thus employed to decompose the generating acetate, why will it not do it, when a piece of the lead in a pot dips into the acid, for in this case only acetate is the result.

* Berzelius' Elements of Chemistry.

To this it may be answered that from the known superior energy of the acetic acid, it forms an acetate with great rapidity, the small crystals of it below acting with capillarity to convey the acid to the upper portions of the metallic coil, while the slowly disengaged carbonic acid can affect the merely moistened crystaline mass with difficulty, and certainly not materially, excepting on its surface. The conclusion, then, is that the process is substantially the same as in Thènard's method, after the lead is oxidized by a moist atmosphere, viz., that a sub-acetate is formed which is simultaneously decomposed by carbonic acid, and that the more neutral salt thus generated being again rendered basic by another portion of oxide is again decomposed, while the final formation of an acid salt is prevented by the gradual escape of a portion of the vinegar. We are not, however, left in doubt as to the latter point, for it has been found that a peculiar etherial substance is obtained during the process, called *acetone*, which may be obtained by passing acetic acid through a heated glass tube, or by the dry distillation of an acetate. It is composed, according to the views of the best chemists, of 3 vol. carbon + 6 vol. hydrogen + 1 vol. oxygen, and its origin from acetic acid may be thus expressed,

1 atom acetic acid, - - -	4 C + 6 H + 3 O
Subtract 1 atom carbonic acid, -	C + 2 O
There remains 1 atom of acetone, -	3 C + 6 H + 1 O

so that acetic acid is resolved into acetone and carbonic acid. By heating the neutral dry acetate of lead, it fuses and evolves carbonic acid and acetone to a given point, when it congeals and forms a basic (two-thirds,) acetate, which requires a higher temperature for its decomposition. One-third of the acetic acid in the neutral salt is thus decomposed, and there remains a basic salt.* Now if the above given explanation of the formation of carbonate of lead be correct, then from the middle, towards the close of the process, when a neutral salt will be forming, the constant presence of a considerable amount of heat will tend to form acetone and carbonic acid, the former of which escapes into the atmosphere, while the latter assists in decomposing the basic acetate which remains. The latter is thus re-resolved into a neutral salt to be again subjected to the same decomposition as before. It might be supposed that this theory would account for the formation of all the carbonate of lead, but it has been shown above that the quantity of vinegar is too small as compared with the metallic lead, and from the relative amount of the two, the

* Wöhler in Berzelius' Chemistry, vol. viii, p. 698.

conversion of the greater part of the lead into its carbonate must be explained on Thènard's principle.

These views of the author were first cursorily expressed in a report by the Franklin Institute, (Journal for 1839,) and I find that the same views are held by Mitscherlich, in vol. ii. of his Elements, Berlin, 1840. Benson alludes to a similar view, (Jour. Fr. Inst. vol. xxv. p. 197,) but refers it chiefly to his process, (see above.) I have given my opinions more at large on this subject, since some of the most eminent chemists have advanced the opinion, and I believe it is generally held, that the formation of carbonate of lead by the old process depended mainly on the decomposition of acetic acid.

C. Newer processes.—I have understood that experiments were performed many years since, with the view of making white lead, by the introduction of vapour of vinegar, air, and carbonic acid, into heated apartments containing lead, but as I am unable to find the authority for this, I shall pass to those with which I am acquainted.

Mr. E. Clark took out a patent in 1828 for a process for making white lead in close chambers, heated by steam, into which he introduced carbonic acid and air, the vinegar being in a trough, and running through the chamber, and heated by steam passing through its double bottom, (Jour. Fr. Inst. vol. xxv. p. 232.) Richards' patent was taken out subsequently, and differed in the introduction of steam into the chamber, besides some minor differences of arrangement. I should suppose that the vapourized vinegar would afford sufficient steam, as in the first patent, the object being merely to ensure the action of the other materials.

It will be observed that the process, chemically speaking, is the same in these patents, as in Thènard's method, or the older processes, viz., that an oxide and acetate are formed and decomposed by carbonic acid.

The carbonate formed by the above processes, the older and newer, is composed of two atoms of carbonate, and one of hydrate of lead, but the difference between them and Thènard's lies in the crystaline granular state of the latter, while in the former "the lead has not departed from the solid state," and is therefore more compact or amorphous, and has greater body. A portion of white lead manufactured according to Clark's process was exhibited at the Franklin Institute last Fall, and pronounced equal to the others, it not being known at the time that it was thus manufactured. A sample of Richards' is in the Technical Cabinet of the Franklin Institute.

The main question relative to the newer processes touches their economy, a point which we do not propose to discuss, as foreign to the nature of this essay. Certainly they offer greater neatness of ar-

rangement, and avoid the heavy losses from breakage of pots, while the materials employed are economical, but then again they require their peculiar expenditure for the production of carbonic acid and steam.

III. Processes dependent on double elective affinity.—The principle of these processes is not novel, although various patents have been taken out latterly based upon it, depending on the precipitation of a salt of lead by a carbonated alkali. Some are simple, others of a very complicated character, as the following selections will show.

Hemming's Lond. Jour. vol. xii. Nitrate of soda is decomposed by sulphuric acid, by which nitric acid is obtained, and sulphate of soda. The sulphate of soda is decomposed by charcoal, chalk, &c., and a carbonate of soda produced. The nitric acid first obtained is employed to form a nitrate with lead or its oxide, and this in solution is precipitated by the carbonate of soda. Thus we have obtained a carbonate of lead and nitrate of soda, the latter of which is again decomposed as above. To say the least of it, the process is highly ingenious, and involves not a little chemical knowledge, while like Thènard's process the original salt is recovered, excepting an allowance for accidental waste.

Watt & Tebbutt's patent, Lond. Jour. vol. xiii. Chloride of sodium, (common salt,) and litharge are heated to make chloride of lead. Three parts of the latter are mingled with one of red lead, and sulphuric acid added, while steam heat is applied. There remains sulphate of lead, and chlorine is evolved. The sulphate is then treated with carbonated alkali, which, according to the patent, will make hydrate with a little carbonate of lead, through which carbonic acid is passed, to fully carbonate it. The chloride of lead is also treated with nitric acid, and carbonated in a similar manner. Farther, lead is dissolved in nitric acid, and precipitated by a caustic alkali, or earth. This patent is evidently complicated, perhaps too much so for practical purposes, and unless the patentee employs a mixture of carbonated with caustic alkali, I do not know how he is to obtain a hydrate with a little carbonate; I would rather reverse it, and say carbonate with a little hydrate. By employing red lead with the chloride, the metal is oxidized by it, so that chlorine, and not hydrochloric acid, is the result; but why should the evolution of chlorine be connected with a white lead establishment?

Leigh's patent, Rep. Pat. Inv. vol. xiv, 1840, employs first, nitric acid to act on galena, to obtain a nitrate of lead; 2nd, carbonate of ammonia purified from gas liquor, or from the distillation of organic substances; 3rd, decomposes the nitrate by this carbonate, obtaining carbonate of lead and nitrate of ammonia; 4th, decomposes the sul-

phate, or chloride, of lead by carbonate of ammonia. In consequence of the amount of litharge produced collaterally in several branches of art, the action of nitric acid on galena appears to be no improvement, particularly as a portion of the acid is decomposed and lost, by yielding oxygen to the lead to form the whole of the oxide. If the carbonate of ammonia can be obtained at a cheaper rate than those of soda, or potassa, and of a sufficient degree of purity, the process might be a good one, but this may be questioned, and even if a sulphate or a muriate of ammonia, be obtained, for which there is a ready sale, I question whether the process would then be economical.

It is not necessary to enumerate more of these highly chemical processes, for it must be evident to any one acquainted with the present state of chemical science, that they might be varied "ad infinitum." The main questions are the economy of the processes and the quality of the material produced. In reference to the former point, I would merely remark that I doubt much whether such processes can be successful, where the only object is the manufacture of white lead; they ought to be connected with other chemical manufactures, the various processes of which should be "dovetailed" into each other, so that collateral products may be wrought up to other products of great utility in the arts. I have not yet seen a good analysis of white lead made by these chemical processes, but from my own experiments I believe it will prove to be like the others, a mixture of hydrate and carbonate, for upon precipitating concentrated solutions of carbonate of soda and acetate of lead, carbonic acid is uniformly generated, and escapes with slight effervescence. With a pure basic acetate this does not take place, because the carbonic acid which would have escaped unites with the soda. The decompositions may be thus illustrated.

Carbonate of soda,	C O^2	-	Carbonic acid.
	2 C O^2	-	Basic carbonate of lead.
	3 N a O	-	Acetate of soda.
Neutr. acet. of lead,	3 $\overline{A}$	-	Acetate of soda.
	3 P*b* O	-	Basic carbonate of lead.
Carbonate of soda,	C O^2	-	Acet. and carb. of soda.
	2 C O^2	-	Basic carb. of lead.
	3 N *a* O	-	Acet. and carb. of soda.
Basic acet. of lead,	2 $\overline{A}$	-	Acet. and carb. of soda.
	3 P*b* O	-	Basic carb. of lead.

So that in either case a basic carbonate of lead results, the excess of oxide uniting with a proportion of water to form a hydrate. It would, therefore, appear that the white lead thus produced is similar to that resulting from Thènard's principle, under all its modifications.

Whether it forms as good a pigment as that produced by the older processes I cannot determine, having never heard the results of its application.

Conclusion.—Mulder, (before quoted, Bullet. d. Sci. &c., in Neerlande I., p. 302,) examined a white lead made by a process lately patented by Stratingh, and found it to consist of three atoms of carbonate, and one of hydrate. This method of manufacture, which I have not seen described, has a decided advantage over others, by its not becoming yellow in as short a time when employed as a pigment, and Mulder therefore believes that the hydrated oxide is the principal cause of this change of colour, as sulphuretted hydrogen affects the carbonate less than the hydrate. That this view is correct is shown from the great tendency to become yellow possessed by the compound containing one atom each of carbonate and hydrate. (See the commencement of this essay.) The ordinary carbonates will absorb a certain quantum more of carbonic acid, but never so much as to expel all the water and form a neutral salt. This curious fact seems to show that there is a stronger affinity between the hydrate and carbonate than between carbonic acid and oxide of lead, to form a neutral salt, and from all the above processes it is evident that there is a superior tendency to form a compound, consisting of two atoms of carbonate and one atom of hydrate.

It appears, then, from the preceding, that we are acquainted with at least three distinct varieties of white lead:

Hydrotricarbonate, - $(Pb0+H0)+(Pb0+C0^2)$
Hydrobicarbonate, - $(Pb0+H0)+2(Pb0+C0^2)$
Hydrotricarbonate, - $(Pb0+H0)+3(Pb0+C0^2)$

Physical Science.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

A new method of involving Polynomials to any power. *By* Wm. J. Lewis, Civil Engineer.

Having directed my attention, some months since, to the method given in all our treatises on Algebra, for the involution of expressions consisting of several terms to any power, it occurred to me that a more expeditious mode might be devised, and by pursuing the investigation given below, I discovered the law by which the co-efficient of any term is found.

If we raise, by actual multiplication, any binomial $a+b$ to any power, we soon find:

First.—That the first term of the expression is a raised to the given power.

Second.—That the second term is a affected with an exponent one less than the index of the power multiplied by b, and having for a co-efficient the index of the power.

Third.—That in each succeeding term the exponent of a is one less, and the exponent of b one greater than in the preceding term.

Let an expression $a+b+c+d+e$, consisting of at least as many terms as there are units in the index of the given power, be required to be raised to the fifth power.

From what we have stated in relation to the second term of a binomial, it will be perceived, *by confining our attention to this second term, and disregarding, for the present, all other terms;* that

$$\overline{a+b}^2 = 2\,a\,b+\&c.$$
$$\overline{a+b+c}^3 = \overline{(a+b)+c}^3 = 3\,(a+b)^2c+\&c.$$
$$\overline{a+b+c+d}^4 = \overline{(a+b+c)+d}^4 = 4\,(a+b+c)^3d+\&c.$$
$$\overline{a+b+c+d+e}^5 = \overline{(a+b+c+d)+e}^5 = 5(a+b+c+d)^4e+\&c.$$

Now we know the value of the first term of the development of each of the expressions on the right of the page. Hence, *confining our attention to this first term, and disregarding all the others,* we have;

$$\overline{a+b}^2 = 2\,a\,b+\&c.$$
$$\overline{a+b+c}^3 = 3\,(a+b)^2c+\&c. = 3\,a^2c+\&c.$$
$$\overline{a+b+c+d}^4 = 4\,(a+b+c)^3d+\&c. = 4\,a^3d+\&c.$$
$$\overline{a+b+c+d+e}^5 = 5(a+b+c+d)^4e+\&c. = 5\,a^4e+\&c.$$

Consequently, by substitution, we have

$$(a+b+c+d+e)^5$$
$$= 5\,(a+b+c+d)^4e+\&c. \quad \text{first term} = a^5$$
$$= 5.4\,(a+b+c)^3de+\&c. \quad \text{“ “} = 5\,a^4e$$
$$= 5.4.3\,(a+b)^2cde+\&c. \quad \text{“ “} = 5.4\,a^3de$$
$$= 5.4.3.2\,abcde+\&c. \quad \text{“ “} = 5.4.3\,a^2cde$$
$$\text{“ “} = 5.4.3.2\,abcde$$

Hence, if P = co-efficient of $abcde = 5.4.3.2$, $\frac{P}{2}$ = co-efficient of a^2bcd, $\frac{P}{2.3}$ = co-efficient of a^3bc, $\frac{P}{2.3.4}$ = co-efficient of a^4b and $\frac{P}{2.3.4.5}$ = co-efficient of a^5.

If instead of $\overline{a+b+c+d+e}^5$ we had examined the equivalent expression $\overline{e+b+c+d+a}^5$, we should have found as terms in the development e^5, $5ae^4$, $5.4ade^3$,&c., from which we perceive that the co-

efficients of the powers of a multiplied by any number of other terms, are also the coefficients for like powers of each of the other letters multiplied by the same number of other terms.

From the results obtained in the preceding investigation we learn *that the co-efficient of the product of as many letters, as there are units (n) in the index of the powers, is n. n—1 n—2 ... 3.2.1.* The introduction of additional terms into the root will not change the value of this co-efficient, as no more than n terms can enter into any expression in the development.

We also remark that a is changed into a^2 by dividing the co-efficient of the term involving a by 2, a^2 into a^3 by dividing its co-efficient by 3, a^3 into a^4 by dividing its co-efficient by 4, &c. Hence we infer generally;

That the co-efficient of a term involving a letter affected with an exponent one greater than in a preceding term, is found by dividing the co-efficient of the preceding term by the greater exponent.

And conversely; *That the co-efficient of a term involving a letter affected with an exponent one less than in a preceding term is found by multiplying the co-efficient of the preceding term by the greater exponent.*

I have demonstrated the truth of these rules for the powers of any letter united to the simple product of other letters. It remains to be proved that it is equally applicable to terms involving combined powers of letters, as a^2c^2e, a^2c^2&c. Let N be the co-efficient of a^2dc^2 and put $c=m+n$, then $Na^2ec^2=Na^2d(m+n)^2=2Na^2dmn+$&c. Hence $N=\frac{1}{2}$ the co-efficient of $a^2dmn=\frac{1}{2}$ the co-efficient of $a^2cde=\frac{P}{2.2}$.

Again let m be the co-efficient of a^2c^3 and putting $c=m+n$ as before; we have $ma^2c^3=ma^2(m+n)^3=3ma^2m^2n+$&c. Hence $m=\frac{1}{3}$ the co-efficient of $a^2mn=\frac{1}{3}$ the coefficient of $a^2dc^2=\frac{P}{2.2.3}$.

The same process applied to any combination of the powers of the letters, which enter into the development of the involved polynomial, will evidently shew, that the co-efficients are determined by the rules which have been given.

It will also be perceived that all similar combinations of the powers of the different terms, must have like co-efficients, and, consequently, it is only necessary to obtain one of each set of co-efficients to enable us to unite the development of the involved polynomial.

Let us now find all the co-efficients, and express in a series the value of $(a+b+c+d+e)^5$.

Here we have $P = 5 \times 4 \times 3 \times 2 = 120$; and for one set of terms and co-efficients.

$$P\ abcde = 120abcde$$
$$\frac{P}{2}\ a^2bcd = 60\ a^2bcde$$
$$\frac{P}{2.2}\ a^2b^2c = 30\ a^2b^2c$$
$$\frac{P}{2.3}\ a^3bc = 20\ a^3bc$$
$$\frac{P}{2.2.3}\ a^3b^2 = 10\ a^3b^2$$
$$\frac{P}{2.3.4}\ a^4b = 5\ a^4b$$
$$\frac{P}{2.3.4.5}\ a^5 = a^5$$

Hence $(a+b+c+d+e)^5$

$= a^5+b^5+c^5+d^5+e^5$
$+5\ a\ ,\ \overline{b+c+d+e}+5\ b^4\ \overline{a+c+d+e}+5\ c^4\ \overline{a+b+d+e}+$
$5\ d^4\ \overline{a+b+c+e}+5\ e^4\ \overline{a+b+c+d}$
$+10\ a^3\ \overline{b^2+c^2+d^2+e^2}+10\ b^3\ \overline{a^2+c^2+d^2+e^2}$
$+10\ c^3\ \overline{a^2+b^2+d^2+e^2}+10\ d^3\ \overline{a^2+b^2+c^2+e^2}$
$+10\ e^3\ \overline{a^2+b^2+c^2+d^2}$
$+20\ a^3\ \overline{bc+bd+be+cd+ce+de}+20\ b^3\ \overline{ac+ad+ae+cd+ce+de}$
$+20\ c^3\ \overline{ab+ad+ae+bd+be+de}+20\ d^3\ \overline{ab+ac+ae+bc+be+ce}$
$+20\ e^3\ \overline{ab+ac+ad+bc+bd+cd}$
$+30\ a^2b^2\ \overline{c+d+e}+30\ a^2c^2\ \overline{b+d+e}+30\ a^2d^2\ \overline{b+c+e}$
$+30\ a^2e^2\ \overline{b+c+d}+30\ b^2c^2\ \overline{a+d+e}+30\ b^2d^2\ \overline{a+c+e}$
$+30\ b^2e^2\ \overline{a+c+d}+30\ c^2d^2\ \overline{a+b+e}+30\ c^2e^2\ \overline{a+b+d}$
$+30\ d^2e^2\ \overline{a+b+c}+60\ a^2\ \overline{bcd+bce+cde}+60\ b^2\ \overline{acd+ace+cde}$
$+60\ c^2\ \overline{abd+abe+bde}+60\ d^2\ \overline{abc+abe+bce}+60\ e^2\ \overline{abc+abd+bcd}$
$+120\ abcde.$

Again, let it be required to find the co-efficients of $(a+b+c)^3$.

Here $P = 3 \times 2 = 6$, and the following terms involve the required co-efficient; P (6) $a\,b\,c$, $\frac{P}{2}$(3) $a^2\ b$ and $\frac{P}{2.3}$ (1) a^3.

As a third example, let us find the co-efficients of $(a+b+c+d)^4$.

Here $P = 4 \times 3 \times 2 = 24$, and the following terms include the co-efficients; P (24) $a\ b\ c\ d$, $\frac{P}{2}$ (12) $a^2\ b\ e$ $\frac{P}{2.2}$ (6) $a^2\ b^2$ $\frac{P}{2.3}$ (4) $a^3\ b$, and $\frac{P}{2.3.4}$ (1) a^4

It is manifest that in all these examples, we could have commenced with the co-efficient of the highest power of a, that is with units, and deduced from thence the remaining co-efficients by successive multiplications and divisions. The expansion of $\overline{a+b+c+d}$ &c.^{n} will exhibit this process in its most general form; it will be

$\overline{a+b+c+d,}$ &c.^{n}

$$= a^n + n\,a^{n-1}b + n.\,\overline{n-1}\,a^{n-2}b\,c + n.\,\overline{n-1}.\,\overline{n-2}\,a^{n-3}bcd + n.\,\overline{n-1}.\,\overline{n-2}.\,\overline{n-3}\,a^{n-4}bcde + \&c.$$

$$+ n.\,\frac{n-1}{2}\,a^{n-2}b^2 + n.\,\frac{n-1}{2}\,\overline{n-2}\,a^{n-3}b^2c + n.\,\frac{n-1}{2}\,\overline{n-2}\,\overline{n-3}\,a^{n-4}b^2cd + \&c.$$

$$+ n.\,\frac{n-1}{2}\,\frac{n-2}{3}\,a^{n-3}b^3 + n.\,\frac{n-1}{2}\,\frac{n-2}{3}\,\overline{n-3}\,a^{n-4}b^3c + \&c.$$

$$+ n.\,\frac{n-1}{2}\,\frac{n-2}{3}\,\frac{n-3}{4}\,a^{n-4}b^4 + \&c.$$

If c, d, &c. each becomes o, the root reduces to a binomial, and all the terms containing these letters disappear from our expression of the power. Consequently we have,

$$\overline{a+b}^n = a^n + n\,a^{n-1}b + n\,\frac{n-1}{2}\,a^{n-2}b^2 + n.\,\frac{n-1}{2}\,\frac{n-2}{3}\,a^{n-3}b^3 + \&c.$$

which is the well known binomial theorem. Where the exponent of the power is not much greater than the number of terms in the root it is better to commence with the co-efficient P, supplying the place of the number of terms which are necessary to make the whole number of terms equal to the exponent of the power, by other letters, the value of each of which is of course nothing. The terms involving these letters are evidently nothing, and the only object of their introduction is to facilitate the calculation of the co-efficients of the remaining terms.

Thus were it required to find the co-efficients of $\overline{a+b+c}^5$, they would be most readily found, by first obtaining the co-efficients of $\overline{a+b+c+d+e}^5$, as in our first example, and then rejecting the first two results, which involve d and e. But where the number of terms is small, and the exponent of the power large, it is more convenient to find the co-efficient of a binomial in the usual manner, and obtain from thence the additional co-efficients, which enter into the power in consequence of the introduction of other letters into the root. For an example, find the co-efficients of $\overline{a+b+c}^{10}$. Here the terms involving the binomial co-efficients are $a^{10} + 10\,a^9b + 45\,a^8b^2 + 120\,a^7b^3$

$+210\ a^6b^4+252\ a^5b^5$, and the introduction of the third term c gives us the following and similar terms.

$$90\ a^8b\,c+360\ a^7b^2c+840\ a^6b^3c+1260\ a^5b^4c$$
$$+1260\ a^6b^2c^2+2520\ a^5b^3c^2$$
$$+3150\ a^4b^4c^2+4200\ a^4b^3c^3$$

We may also remark that the co-efficient of any term is easily found without regarding the co-efficient of any other term. Thus the co-efficient of $a^5b^3c^2$ in the above example is evidently

$$\frac{10.9.8.7.6.5.4.3.2}{(5.4.3.2)(3.2)2}=\frac{10.9.8.7.6}{3.\ 2.2}=2520.$$

Here the numerator represents the value of P, and the denominators the several divisors used in converting products to squares, squares to cubes, &c. The general expression for the co-efficient of $a^rb^sc^t$ is (putting $n=r+s+t=$ the exponent of the power)

$$\frac{n.\ \overline{n-1}\ \overline{n-2}\ .\ .\ .\ .\ .\ .\ .\ .\ \overline{r+1}}{(s\ \overline{s-1}\ \overline{s-2}\ .\ .\ .\ 3.2)\ (t.\ t-1\ t-2\ .\ .\ .\ 3.2)}$$

Franklin Institute.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on Tatham & Brothers' Lead Pipes.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination the Patent Improved Leaden Pipe manufactured by Messrs. Tatham & Brothers, of Philadelphia, Pennsylvania, Report:

That they have carefully examined many specimens of these pipes selected by themselves and subjected them to repeated trials by a suitable force pump. The pressure was cautiously increased until the bursting point was attained, in every instance, and the phenomena accurately observed. From the result of these trials the committee are unanimously of opinion that these pipes possess some important advantages over those heretofore used.

1st. *The strength* is equal to the maximum strength of lead due to the form and weight of the tube; thus exhibiting a rare coincidence between theoretical and practical perfection in this respect. The uniformity of the thickness and perfect accuracy of the bore which are attained by the mode of manufacture ensure this invariably. Experiments on the strength of leaden pipes exhibit many discordant and embarrassing characters which have occasioned the Committee some

anxiety. It is well known that the presence of a small proportion of tin, or other metal with which lead is usually alloyed, always affects its hardness and strength—so that pipes made precisely in the same manner, of lead procured from different, and even from the same mines, vary exceedingly in strength. This source of error cannot be ascertained without great difficulty, and the Committee have taken it into consideration.

2nd. *Absence of Flaws.*—As the metal is forced out from the reservoir under enormous pressure, whilst acquiring its form, flaws are avoided, which so often exist in the ordinary castings. It is moreover probable that such pressure whilst consolidating the metal, contributes to its strength.

3rd. *Absence of Scales of Lead and Polish of the Interior.*—These pipes are perfectly clean within, and from the mode of making them must necessarily have this desirable property. The perfect polish also facilitates the motion of fluids.

4th. *Uniformity of Bore.*—The calibre is capable of being made precisely the same throughout, while the common leaden pipes may vary even when made with great care.

5th. *Economy of Metal*—resulting from the concentricity of the interior and exterior surfaces no metal is wasted from variation in thickness.

6th. *The longer lengths* requiring fewer joints, thus diminishing the expense and inconvenience of soldering. These pipes can be made in lengths of from 40 to 300 feet, according to their weight.

7th. Facility of making pipes of large diameter which the Committee believe to be almost impracticable by the ordinary methods, but which may nevertheless be sometimes demanded in the arts.

By order of the Committee,

WILLIAM HAMILTON, Actuary.

Philadelphia, Nov. 11, 1841.

Report on Greenough's Patent Lamp and Chemical Oil.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination the patent lamp and chemical oil, invented by Mr. B. F. Greenough, of Boston, Massachusetts, Report,

That the lamp is one contrived for the purpose of burning those compounds analogous to camphene, which require for their perfect combustion, a strong draft, and a carefully regulated supply of air.

The lamp consists of an inverted bell-shaped reservoir, through the centre of which passes a tube, open at both ends, the upper end

of which is about one and a half inches above the reservoir, while the lower extremity has a free access to air, as in the ordinary Argand lamp.

This tube, of course, passes air-tight through the reservoir. Concentric with this, and surrounding it, is another metallic tube, starting about one-sixteenth of an inch below the upper edge of the wick, and passing down nearly to the bottom of the reservoir, where it terminates. Into the space between these two tubes, the wick, itself secured upon another tube, passes, and rises about three-fourths of an inch above the upper edge of the inner air-tube. In consequence of this arrangement of the wick, the lamp, when filled, may be inverted, or even rolled over the floor, without losing any of its contents.

The top of the reservoir is made flat, and upon it rests a slightly conical tube, a little more than two inches in height, expanded below into a flat zone, around the circumference of which apertures are provided, for the introduction of the air, which is delivered at the upper end of the tube, around the outer circumference of the flame. Along the axis of the inner air-tube passes a metallic stem, which carries, at its upper extremity, a button, or reverberator, of a diameter rather larger than that of the tube upon which the wick is secured. This button may be raised or lowered at pleasure, by means of the stem, and by it the height of the frame is regulated, and perfect combustion insured. The glass chimney is about one foot in height, swelling slightly at the part opposite the flame, and thence gently tapering to its upper extremity.

By means of the contrivances thus described, a constant and steady access of air is secured to the flame, while the effect of any draught, or sudden current, is in a great measure counteracted. The lamp thus burns steadily, and without any apparent flickering irregularity.

The substance proposed to be burned in these lamps, is what is termed by the inventor, "chemical oil." It is evidently derived from oil of turpentine, but the exact chemical composition of it is, to the committee, unknown.

In regard to the light obtainable from the chemical oil in the lamp thus constructed, as well as the economy to be expected from its use, is subjoined the results of the experiments instituted by the sub-committee.

A lamp containing a pint and half a gill of the oil, was suspended and lit precisely at twelve o'clock. The draught was so regulated as to increase the consumption of the material, as far as it could be done, without giving rise to smoke—and that this was the case, was rendered evident from the odour of the unburned oil, which pervaded the room during the day. At eight and a half o'clock, the wick being

considerably clogged, and the light, in consequence, diminished, the lamp was extinguished, and the consumption was found to be five-eighths of a pint. The cost of the oil being one dollar per gallon. This gives an average expense of nine-tenths of a cent per hour. The inventor states the average expense at one cent per hour.

In regard to the intensity of the light, the same lamp regulated, as far as possible, to the same height, was compared with the Argand gas burner, in the committee room, which is a burner of a little less than three-fourths of an inch, and consists of eighteen jets. This light was estimated by Mr. Cresson to be consuming about four and a half cubic feet per hour, which, at the present price of gas, is an expense of 1.575 cents per hour. The relative intensity of the light, (estimated as proportional to the squares of the distances of the centres of the respective flames, from the centre of the photometer, when the lights were equalised,) was 702.25 for the gas; 1482.25 for the chemical oil; or a little more than two to one in favour of the chemical oil.

By the kindness of Mr. Cresson, the committee were furnished with a remarkably fine Argand lamp, with an adjustable chimney, by means of which the draught of air could be regulated to every height of the wick. With these two lamps the relative intensities were—for the Argand lamp, 495.0625; for the chemical oil, 1122.25; or 2.26 to 1 in favour of the chemical oil.

An experiment was then tried with two of Mr. Greenough's lamps, one being filled with the chemical oil, the other with Dyott's pine oil. The relative intensities were for Dyott's pine oil, 1089; for the chemical oil, 1225; or 1.125 to 1 in favour of the chemical oil.

In these experiments, the distances from the centres of the respective flames to the centre of the photometer, when the lights were equalized, were as follows, viz:

From the gas Argand burner, 26½ inches; from the chemical lamp, 38½ inches.

From the oil Argand burner, 22½ inches; from the chemical lamp, 33½ inches.

From the lamp with Dyott's oil, 33 inches; from the chemical lamp, 35 inches.

It should also be remarked that the lamps, burning during these experiments for about two and a half hours, exhibited much less clogging of the wick than in the experiment upon the quantity of oil consumed, and the smell was also much less.

The question of the relative adaptation of oils of this nature, and of ordinary sperm oil, for domestic purposes, will be settled by every one, according to their individual impressions in relation to the danger

in using a substance much more inflammable than common oil, and their estimate of the security attainable from care and proper attention.

This question does not seem, to the committee, to be within their province. Perhaps, however, it may be considered that the greater inflammability of the chemical oil is somewhat compensated by the fact that when spilled upon a surface it leaves no stain.

These questions being left for individual consideration, the committee can, with safety and pleasure, recommend Mr. Greenough's lamp, as admirably adapted for the purposes for which it is intended, and as exhibiting a gratifying specimen of our arts in the gracefulness of its design, and the beauty of its finish.

By order of the Committee.

WILLIAM HAMILTON, Actuary.

Philadelphia, Nov. 11th, 1841.

Mechanics' Register.

LIST OF AMERICAN PATENTS WHICH ISSUED IN NOVEMBER, 1840.

With Remarks and Exemplifications by the Editor.

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1. For improvements in the *Steam Engine applied to Locomotive purposes and Steam Navigation;* John Ericsson, of the Kingdom of Sweden, now residing in New York, November 5.

The claim appended to the specification of this patent will give a sufficiently clear idea of the invention; it is as follows, viz. Having thus fully described the nature of my invention, and shown the manner in which I carry the same into operation, I do hereby declare that I do not claim to be the inventor of steam engines having radial pistons which vibrate or perform partial rotary movements within semi-cylinders, or other segments of cylinders, such engines having been before known and used; but what I do claim as my invention, and desire to secure by letters patent, is the propelling of steam carriages by the combining of two semi-cylinders, each furnished with radial pistons, which pistons vibrate within them, said semi-cylinders being placed on a level with each other; and the shafts, or axles, of their radial pistons extending through the cylindrical covers in opposite directions beyond the sides of a locomotive carriage, and having crank levers attached to their outer ends, which crank levers are connected by suitable rods, to crank pins on the driving wheels. The respective parts being combined and arranged substantially in the manner herein set forth. I likewise claim the employment of the same apparatus for the driving of the propelling, or paddle, wheels of such vessels as are propelled by the power of steam; the general arrangement and operation of the respective parts being substantially the same with those by which said combined semi-cylinders are adapted to the propelling of loco-

motives, with such variations of arrangement only as are required by the nature of the case, and as herein fully pointed out and made known. I also claim the combining of the double semi-cylindrical air-pump with my double semi-cylinder steam engine, constructed and arranged as herein set forth. Said air pump having a radial vibrating piston, and self acting valves, and being arranged and connected with the other operating parts of the engine, substantially as herein described."

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2. For an improvement in *Portable Ovens and Stoves;* Edward Gosselin, city of New York, November 7.

This patent is for adapting a portable and shifting oven to a cooking stove, the draught of which passes under the top plate. The top plate of the stove is provided with two apertures, one near the front, and the other near the chimney; there being a damper in front of the rear aperture, which, when opened, admits the draught to pass directly out at the chimney, and when closed directs it around the oven, the flue of which is made to fit the two openings in the top plate of the stove, so that the draught passes up at one end of the oven, over the top, down the back and out at the chimney.

Claim.—"What I claim as new and of my own invention, and desire to secure by letters patent, is not the mere combination of a portable oven with a cooking stove, as this is not new, but the combining the oven with the stove in the manner herein set forth, so that the draught from the stove shall pass up on one end of the oven, over the top, and down on the opposite end into the common flue of the stove; that is to say, I claim the combination of an oven constructed in the manner herein set forth, with any cooking stove adapted to receive it, and so regulated as to admit the draught either to pass over the oven and thence into the common flue, or to pass directly into the flue without circulating over the oven, the whole being constructed substantially in the manner herein set forth."

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3. For making *Water-proof Trunks;* Peter Getz, Lancaster, Pennsylvania, November 7.

The proposed improvement is adapted to the common trunk, the space in the top, or lid, being made air tight with tinned copper. A box that fits into the body of the trunk, is also made of tinned copper, covered on the top with wood. Into this top is made a hole with a metal ring fitted to it, to receive a cover that screws into this ring, there being a similar ring attached to a copper plate which constitutes the cover. The key hole is made water tight by a screw cap in the same manner with the cover of the box. The whole being thus made water tight, and the upper part or lid of the trunk being an air chamber, the articles contained in the box will not only be preserved from moisture, but the whole may be used as a life preserver.

The claim is confined to the "method described of rendering trunks

water-proof by constructing them with a screwed plate, or lid, in the manner set forth."

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4. For an apparatus for *Cooling Mash in Distilling Operations;* Allen D. Ward, Mason county, Kentucky, November 7.

The improvement which is the subject of this patent is applied to the common mash rake. A water receiver is placed on the top of the rake beam and surrounding the shaft, and another at the bottom of the mash tub, and also surrounding the shaft. Two pipes, one on each side, extend from the upper to the lower receiver; they are curved so as to extend from the upper receiver to the outer rake teeth, in front of which they are then curved and run up in front of the next teeth, and so on until they reach the receiver at the bottom of the mash tub. Water is supplied to the upper receiver and passes through the serpentine pipes to the lower receiver and is discharged at the bottom thereof, and in passing through the pipes, which are carried around with the rake, cool the mash.

The claim is to the "combination of the serpentine pipes and receivers with the shaft for cooling the mash speedily in warm seasons, after the operation of mashing is accomplished."

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5. For improvements in the *Printing Press;* Stephen P. Ruggles, Boston, Massachusetts, November 10.

This press, we are told by the patentee, is principally adapted to small work, such as the printing of cards, and bills. The platen is raised and lowered by a toggle joint, and the types are placed with their face downwards, what is usually called the bed plate, being in this press placed above the platen. The paper is placed on a movable tympan plate, and the impression is given by raising the platen, which first comes in contact with the under side of the tympan plate, and forces it up, with the paper, against the types. The paper is put on and removed, and the types inked by the operation of the machinery, which is all worked by one person; but as the arrangement is necessarily complex, and the claims refer throughout to the drawings, they would not be understood if given.

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6. For an improvement in the mode of *Shifting Switches on Railroads;* Jesse La Rue, Bucks county, Pennsylvania, November 10.

In this apparatus a bar is jointed to the single or double switch, and to this bar is jointed two levers, in opposite directions, and nearly in the middle of the track—when the single switch is used, one lever is placed in the middle of each track. That end of the levers opposite to the end which is jointed to the bar, is weighted to counterbalance the weight of the switch and bar, and properly curved to be acted upon by a cam piece attached to the forward part of the car. By this arrangement the car will always act upon the switch before it is reached by the wheels when running in either direction. The cam

piece which acts on the levers is permenantly attached to the forward part of the car. The end of the rail, and of the switch against which it fits, are beveled so that stones and dirt will not be retained by them.

Claim.—"I am aware that switches have been shifted by the motion of the cars running on the rails leading thereto, and do not therefore claim this as making any part of my invention; but what I do claim, and desire to secure by letters patent, is the combination, in the manner set forth, of the switches, connecting rod, and the two levers, furnished with the curved metallic castings acting as a counterpoise to the weight of the switches, and acted upon by what I have denominated the operating power, (cam piece attached to the car,) whereby the switches may be shifted before they are reached by the car, the same being effected by the car itself, when traveling in either direction, as set forth. I also claim the beveling of the ends of the switches, and of the rails, for the purpose and in the manner above made known."

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7. For a machine for *Cutting Nails, Brads, &c.;* Geo. D. Strong and Jona. Dodge, assignees of Walter Hunt, city of New York, November 13.

This machine is principally applicable to the cutting of nails, such as were patented by Walter Hunt on the 12th of November, 1839, and noticed in the 1st volume, 3rd series, of this Journal, page 18. The cutters are made by turning, or otherwise forming, metallic staves or longitudinal sections of zones, or thimbles, so that their outer peripheries shall represent the form of one half of the nails, or brads. Two such cutters are attached, by their ends, to levers united so as to vibrate together upon gudgeons attached to their outer faces; the centre of vibration of the double lever corresponding to the centre of the circle forming the outer peripheries of the cutters. Two similar cutters, arranged in the same manner, are placed below, so that when the two sets of levers vibrate, the edges of the two sets of cutters just pass each other, they being reversed for that purpose. The cutting edges of the two cutters, on each double lever, are sufficiently far apart to admit of the passage of the bar of iron, from which the nails are cut between them during their vibration. The two sets of levers are connected together by joint links so as to insure their simultaneous vibration. Thus it will be seen that when the two sets of levers are vibrating in one direction, the cutter on one end of the lower set of levers will unite with the cutter on the other end of the upper set of levers in cutting a nail with the head on one side of the bar of iron, and when making the return vibration the other set of cutters will cut the nail with the head on the other side of the bar.

There is a spring gauge to gauge the feed of the bar at every cut—it consists of a long spring attached to the outside of one of the lower levers with a horn, or projection, passing between the two lower cutters.

Claim.—"I claim the plan of forming the cutters for cutting nails, brads, &c., from staves or longitudinal sections of metal zones, or

thimbles, in the form, or forms, specified, whether the same are first made, or turned in entire pieces and afterwards cut, or sawed, into sections, or whether said sections are fitted up separate, or made of cast steel, or other metal. I also claim in connexion with said above described cutters, or those of any other form, having similar shaped cutting surfaces, or edges, the mode of arranging the same in such manner as to operate upon the same principle of motion, that is to say, arranged in two opposite pairs fitted in levers, or other fastenings, by the vibrating motion of which levers two opposite cutters, one from each pair, is made to approximate and pass each other, operating as cylindrical shears in cuting off one nail, and as those recede, the other pair operate in a similar manner in cutting the next nail, alternately. And I further claim the combination and general arrangement of the head knives, cutters, and spring gauge, constructed and arranged as above set forth and described, without reference to the particular form of the cutting edges of the cutters for the purpose of cutting nails, brads, tacks, &c., without regard to the particular form or shape of the same."

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8. For an improvement in *Door Springs;* Wm. W. Smith and Ben. Mullikin, Jr., city of New York, November 13.

From the arbor of a crank having its bearings in a frame attached to the casement of the door, a lever projects, the extreme end of which passes through a loop in an arm attached to the upper edge of the door. The lever is at right angles to the crank, and the crank is actuated by a spiral spring, one end of said spring being attached to the crank and the other to the casement of the door. By this arrangement it will be perceived that the tension of the spring will tend to close the door until it is opened to a right angle, which places the crank in the dead point, and keeps the door open, and when it passes this point the effect will be to force it still further back.

The claim is to the "combination of the spring, crank, and lever, acting upon the arm attached to the door, or gate, in the manner and for the purpose described."

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9. For an improvement in the method of *Manufacturing Balls or Shot;* Levi Magers, city of Baltimore, November 13.

The moulds, which are to be used are made upon the sides of any number of square bars of iron, are arranged in a reciprocating carriage, so that they can be separated at the end of each operation to discharge the balls that have been cast, and then reclosed. For this purpose the bars slide on the carriage at right angles to its length, and all the bars are connected with one lever, each by a separate link, the connecting link of the outside bar being furthest from the fulcrum of the lever, and the others nearer and nearer the fulcrum, so that by one movement of the lever the bars will all be separated. A furnace and kettle, containing the lead, are arranged over the carriage of moulds, and are provided with the necessary appendages to allow the molten lead to run into the moulds as they pass under the kettle, and

to stop its flow when the carriage of moulds arrives at the end of its course.

The claim is to the combination of the furnace and kettle with the moulds, and also to the combination and arrangement of the moulds with the carriage.

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10. For an improvement in the *Windlass Bedstead;* Thomas Lamb, Washington, District of Columbia, November 13.

In this bedstead the rail and post are to be put together by a round tenon and mortise, the mortise being provided with a pin that fits in a groove turned in on the outside of the tenon. A longitudinal groove is cut in the end of the tenon which slips over the pin when the tenon is inserted in the mortise. A segment of a ratchet wheel on the end of the rail, and a pall on the post, constitute the windlass.

The claim is to the above mode of attachment in combination with the windlass.

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11. For a machine for *Sawing Paving Blocks;* Amaziah Nash, Calais, Washington county, Maine, November 13.

The blocks are to be cut by means of a circular saw, and the improvement is in the method of presenting the block to the saw. The block to be sawed is placed on the upper end of a spindle, which has its bearings in a slide, that works in, and at right angles to, the carriage. A frame is either attached to the top or bottom of the slide above mentioned, and when the frame is placed above, the block is shifted, to be cut into any given number of faces, by an index, or "notched wheel and catch," the arbor of which slides up and down by means of a lever to take hold of the block, and when placed below, the spindle on which the block is placed, has a cog wheel on it to form the connexion between the spindle and the index wheel. The carriage feeds the block up to the saw, and the slide, which works at right angles to the motion of the carriage, regulates the diameter of the block.

The claim is to the combination and arrangement of the carriage, slide, index, and saw.

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12. For improvements in the *Cooking Stove;* David H. Hilliard, Cornish, Sullivan county, New Hampshire, November 26.

The improvements described are to be appended to the stove patented by Thomas Woolson, on the 20th of July, 1831, and noticed at page 47 of the ninth volume of this Journal, second series, but they may be applied to other stoves.

The improvements consist in the manner of constructing or arranging the fire chamber, which constitutes what the patentee terms an "air tight furnace." This furnace is adapted to the hearth plate which is sunk like an ash pit, and the anterior part of the bottom is open like a grate, and to this the ash drawer is adapted. The ash drawer is made with a plate in front, so that when it is under the

grate, a draught of air will be admitted to the fire, but when the plate is pushed under the grate, then the draught will be cut off. At the posterior part of this furnace there is an opening which leads to the oven flue of the stove. When the furnace is to be used, this opening is reduced by means of a strip of metal, and when the opening is to be closed entirely it is effected by another strip of metal attached to one edge of a plate which slides on the top of the furnace and is provided with a collar and cover to receive a tea kettle or other vessel. By this arrangement the furnace can be rendered air tight.

Claim.—"What I claim as my invention and desire to secure by letters patent, is the manner in which I have constructed the bottom of my fire chamber with grated openings through the anterior part thereof, and combined therewith an ash pit drawer having a flat plate in front of sufficient width to cover these openings, and an aperture in the rear for the purpose of admitting air, the whole operating in the manner set forth. And in combination therewith, I claim the strips of metal arranged and operating as described for the purpose of closing the flue space at the back of the fire chamber when required."

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13. For a musical instrument called the *Vocal, or Echo, Organ;* John W. Campbell, Attica, Fountain county, Indiana, November 26.

The object of this improvement is to modify the sound produced by the vibration of a metallic reed, by causing it to pass through chambers, called by the patentee, "vocal, or echo, chambers." Any desired number of these chambers, properly tuned, are arranged in a box which is supplied with wind from a bellows, and the outlets from the chambers are governed by stops attached to keys like those of a piano forte.

Claim.—"What I claim as my invention, and desire to secure by letters patent, is the construction of the vocal apparatus herein described, consisting of the vocal box with its vibrating tongues, as set forth, and the mouth piece and fauces attached to the same. I also claim the placing of the foregoing vocal apparatus, or such number of them as might be necessary to produce the required notes, in a box constructed in the manner herein described. The said vocal pieces being arranged beside each other and governed by stops, operated by keys for producing tone in the manner herein set forth."

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14. For an improvement in *Churns;* Constant Webb, Wallingford, New Haven county, Connecticut, November 26.

This alleged improvement in churns is in that kind which consists of four wings attached to a horizontal arbor revolving in a box, and instead of having the four wings parallel to the axis, and attached by each end to a head, they are attached to a cross at one end only, and incline from the line of the axis at an angle of about thirty degrees.

Claim.—"What I claim as my invention and desire to secure by

letters patent, is the reel, and the manner in which the agitating wing-boards are arranged upon the arms of the cross, and thus form the peculiar reel of the churn, as set forth in the specification, viz: by attaching to each arm of the cross on the arbor, or axle, an agitating wing, made fast to the arm at one end, and passing the line of the axle obliquely to the left, at an angle of about thirty degrees; each wing being about three inches broad at the end by which it is made fast to the arm of the cross and gradually reduced to about half that width, at the other end, and of such length, and so curved, as to approach but not to touch the sides or bottom of the churn, as more particularly described in my specification."

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15. For an improvement in the *Spark Extinguisher;* David Ritter, New Haven, Connecticut, November 26.

At the top of the ordinary chimney of a locomotive steam engine there is placed a cap, pierced with three holes, one at top, one in front, and the third at the back; the two former have hinged covers, which can be opened for firing up, and the other provided with a conducting tube which runs over the engine and turns down at right angles, and is to discharge the sparks, &c., into a reservoir containing water, and covered with wire gauze for the escape of the draught.

Claim.—"I do not claim as my invention, the conductor for carrying off the sparks from the chimney of the locomotive nor the openings for the draught on the top or in front of it, which openings may be used or not as occasion may require. But I do claim as my invention the combination of the cistern or reservoir of water with the conductor for carrying the sparks and dust from the chimney and depositing them perpendicularly downward in the reservoir, and thereby extinguishing the sparks and absorbing the dust, permitting the smoke only to escape from the reservoir."

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16. For a *Rotary Steam Engine;* Jacob C. Robie, Binghampton, Broome county, New York, November 26.

The engine which is the subject of this patent is very similar to many other rotary engines which have been noticed in this Journal, and as the claims refer to the drawings we will not insert them, but make the following extract from the specification, explanatory of the general combination of the instrument.

"My engine is, in its general construction, similar to some other rotary engines which have been heretofore made; my improvement consists in certain devices by means of which the friction is lessened, the waste of steam is prevented, and the valves against which the steam acts, are so constructed and arranged as to open against permanent bearings, so that their action is more perfect, and their liability to derangement much less, than such as have been heretofore constructed."

17. For *Straining and preserving Clothes Lines;* Edwin Allyn and C. B. Hildredth, Boston, Massachusetts, November 26.

The clothes line to be preserved and strained is to be wound upon a bobbin, or spool, the spindle of which is provided with a winch and ratchet wheel and pall. The spool is enclosed within a case having a sliding door in front. When the line is to be used, the sliding door is to be opened, and the end of the line passed through snatch blocks properly arranged, one of which is double, and then attached to a pin.

The claim is to the "combination of a spool, or bobbin, having a windlass ratchet wheel and catch, with a casing having a slide in front, and also with the single and double snatch blocks."

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18. For a *Thrashing Machine;* John Criswell, Cecil Township, Washington county, Pennsylvania, November 26.

This patent was granted for a mode of arranging that part of a thrashing machine by which the grain is separated from the straw, and the straw itself carried away. Behind the thrashing cylinder there is an inclined rack, made like a venetian blind, or shutter, on which the grain and straw are thrown by the cylinder. The straw is drawn up over this rack by a set of rakes, attached to an endless belt, and is discharged at the upper end of the rack whilst the grain falls through between the slats on to an inclined board, and is thence conducted to a proper receptacle.

The claim is to the "forming of the rack as an inclined plane, and carrying the straw over it by a belt of rakes."

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19. For constructing *Cabooses and other Cooking Stoves;* Loftis Wood, city of New York, November 26.

The following extracts from the specification of this patent will give the reader a very clear understanding of the improvement. "The main feature of my improvement consists in the manner in which I heat the oven used for baking, which oven is situated at the back of the fire place, or chamber of combustion, as in the greater number of cooking stoves; but in my cabooses, or stoves, I do not allow of a direct draught from the fire to pass under the oven, but cause the whole of the heated air generated in combustion to pass over the oven, in a flue space between it and the boilers, or other cooking utensils situated above it; whilst I heat the lower part of the oven by constructing the grate upon which the coal, or other fuel, is sustained, with hollow bars, which bars admit the atmospheric air freely into them in front, and open at their inner or back ends, into a flue space under the oven. I perforate the bottom plate of my oven with holes, so as to allow the atmospheric air which has passed through the grate bars, and has thereby become highly heated, to pass directly into the oven; and I also perforate the back plate of my oven with holes through which the heated air which has been admitted into it may escape into the back flue, and thence, under the government of a

damper, valve, or sliding shutter, into the flue by which it is carried to the chimney.

"What I claim," the patentee further says, "as constituting my invention, and desire to secure by letters patent, is the manner in which I construct and combine the grate bars and the oven, as herein described; that is to say, the forming of my grate with hollow bars, the openings through which lead into the flue space under the oven, for the purpose of heating atmospheric air, and conducting it into said flue space; and in combination therewith I claim the opening through the bottom and back oven plates, for allowing the air so heated to pass into and through the oven, its passage being governed by a shutter, or damper, as described."

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20. For a *Portable Furnace for Bathing Tubs;* Randolph Densmore, Hopewell, Ontario county, New York, November 26.

The patentee says—"The kind of furnace which I have improved is that which is so constructed as to float in the water contained in the bathing tub, and in which the burning charcoal is below its surface, the fire being fed with air through two tubes branching out from each side of the ash pit." The furnace, as improved, is cylindrical, and a semi-cylindrical tube passes down the middle of it, from near the top to the ash pit, through which the air is supplied to the fire.

Claim.—"Having thus fully described the nature of my improvement, and shown the manner in which I carry the same into operation, what I claim therein as constituting my invention, and desire to secure by letters patent, is the giving to the body of the furnace for the heating of baths, a cylindrical form, and placing the tube, or tubes, channel, or channels, through which air is supplied to the fire, within said body, in the manner and for the purpose herein set forth. And it is to be understood that although I have mentioned a cylindrical form only, as given to the furnace body, I do not intend thereby to limit myself to this particular shape, as the body may be made oval, or polygonal, or be otherwise varied in form, whilst the instrument will remain substantially the same."

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21. For a machine for making *Splints for Friction Matches;* Norman T. Winans and Thaddeus Hyatt, city of New York, November 26.

The patentees say—"Our new manufacture of splints, or sticks, for matches, consists in the making them by pressure and condensation from wood first cut into thin sheets in the manner of veneers; which sheets, or veneers, many be about an eighth of an inch in thickness. In proceeding to manufacture our splints we divide these veneers into portions of the proper size for subjecting them to pressure by means of suitable instruments, which will at the same time condense the wood, and cut it into strips, or splints, preparatory to their being

dipped into sulphur, or into any composition with which they are to be tipped."

The machine which they describe consists of two rollers, mounted like flatting mill rollers, fluted longitudinally, between which rollers the veneers are passed and are thereby cut and pressed into splints, but not quite separated. Two dies properly fluted may be substituted for the rollers.

The claim is to the "manufacturing of splints, or sticks, for matches, of wood condensed by mechanical pressure between rollers, or dies, as described."

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22. For an improved mode of *Regulating the action of the Waste Steam in Locomotives*, to increase or decrease the draught; Ross Winans, Baltimore, Maryland, November 26.

(The specification will appear in the next number.)

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23. For a mode of *Tubing for Sinking Wells* in alluvial soils; Ebenezer Rice, Salina, Onondaga county, New York, November 26.

The tubes which are to be sunk in bored wells, as described in the specification, are to be made of bored wood in sections, and united by means of two metal ferules at each joint, one of them on the outside let in so as to be flush with the wood, and the other let into the end of each piece mid-way between this and the inside. The lower section of tubing, or pipe, towards the bottom of the well, is to be made of iron. A follower, also made of iron, in two parts, and provided with two ears, is placed on the top, and by means of chains attached to these ears, the force is applied for sinking the tube.

The claim is to the "method of sinking wells in alluvial soils, and marshy grounds, by means of wooden tubing formed in lengths, connected together by metal bands, or hoops, sunk in the ends, together with a metal band on the outside, and provided with a metal tube at the bottom, and also the follower on the top, constructed and applied in the manner and for the purpose described."

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24. For an improvement in the *Cut off Valves of Steam Engines;* Wm. A. Lighthall, city of Albany, New York, November 26.

(See specification.)

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25. For a machine for *Skeining Silk and other Thread;* George Heritage, Chestertown, Kent county, Maryland, November 26.

This instrument is for winding a number of skeins on the same reel, one after another without stopping, until the whole surface of the reel is covered. In front of the reel there are two bars with pins in them, as far apart as the distance the skeins are intended to be separated. One of these bars moves up and down by being connected at each end with a crank on a shaft immediately under it. The bobbin, or spool, from which the silk is drawn, is placed obliquely, so that at

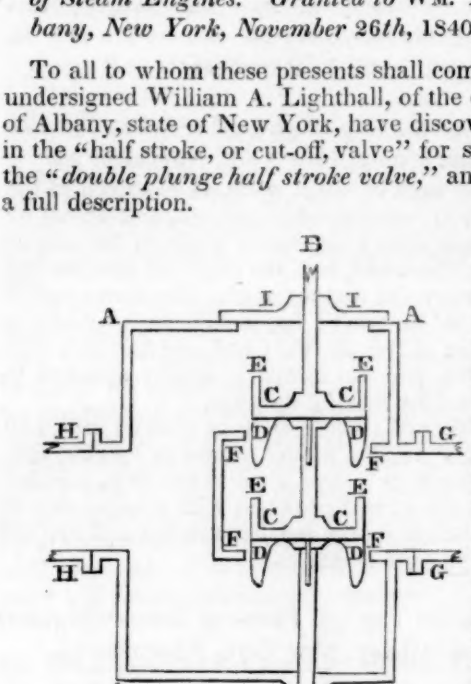
every up and down movement of the bar the silk, or other thread, is shifted one pin, which forms another skein on the reel—at the end of the operation the thread is cut between each skein.

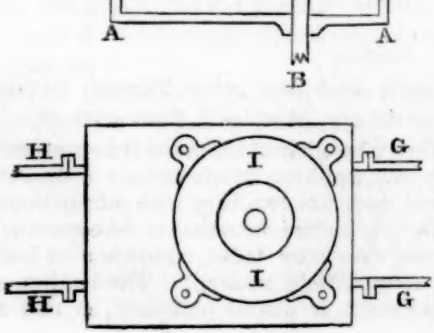
The claim is to the "mode of skeining the silk by the arrangement of the movable and stationary bars and rows of pins in combination with the reel."

Specifications of American Patents.

Specification of a Patent for an Improvement in the Cut-off Valves of Steam Engines. Granted to Wm. A. Lighthall, *city of Albany, New York, November 26th,* 1840.

To all to whom these presents shall come: Be it known that I, the undersigned William A. Lighthall, of the city of Albany and county of Albany, state of New York, have discovered certain improvements in the "half stroke, or cut-off, valve" for steam engines, which I call the "*double plunge half stroke valve*," and of which the following is a full description.





A, A, A, A, The steam chest; B, B, the valve stems; C, C, the plunge valves of equal diameter, with their rims, or collars, E, E, being three to six inches deep in accordance with the required "throw" and recoil of the valve, thus allowing the valves sufficient play, or motion, while they are in the openings, and still continuing to close them. D, D, four lugs, or guides, upon each valve, having their outer edges gradually tapering inwards towards the stem, or rod, which, together with said stem, or rod, secures the entrance of the valves into F, F, the valves, seats, or openings, which being turned, or bored square instead of beveling or conical, allow the cylindrical formed valves to enter in, and partially through, said openings, and work as

plungers with little or no friction. Thus it will be seen that this valve differs in structure and mode of working from any valves now or heretofore used. The collar part of the valves being cylindrical instead of conical, the lugs, or guides, being sufficiently tapered inwards, and the seat or valve openings being also turned square, or cylindrical, on their edges instead of conical, or beveling, the valves work by plunging into, and partially through, the seat, or opening; the lugs, or guides, are never entirely withdrawn from the openings when lifted, but on the return stroke, or motion, may pass completely through the openings; the collars, or rims, still continuing to close the apertures G, G. The opening to the side pipes, H, H; the opening to the steam pipe I, I. The top view showing the top and bonnet of the steam chest.

The whole apparatus will thus be seen to consist of a cast iron steam chest, or box, A, A, A, A, partially divided by an interior apartment, division, or chest, with apertures F, F, for admitting the steam from the exterior into the interior chest. The valves C, C, play, or work, in those openings, and alternately close and open the communication between the steam apartments. The steam pipe H, H, from the boiler opens into the exterior box, or chest, and the steam pipe G, G, to the cylinder communicates with the interior box, chest, or apartment; when, therefore, the valves are out of the openings the steam is admitted from the exterior chest, or apartment, into the interior, and thence to the side pipes upon the cylinder.

The advantages obtained by my improvements in the cut-off valves as set forth in the specification and drawings herewith submitted, may be thus briefly enumerated.

1st. It shuts off the steam more perfectly than the cut-off valves now in use, and sufficiently perfect for all practical purposes of a half stroke valve.

2nd. It requires less power from the engine to work it, because having two valve plates on one stem of equal superfices it is, when in "situ" in equilibrium floating, as it were, in the steam that surrounds it, the least possible force destroys that equilibrium, and admits the steam. In this respect it is an improvement on the ordinary double balance valve, for that requires the diameter or superfices, of one valve plate larger than the other to keep it in its seat; consequently greater force to displace it, to admit the steam, is necessary.

3rd. It works without noise and consequently obviates the wear and tear from the collision which in the ordinary valves occasion that noise. The conical, or beveled, rims, or edges, of the ordinary double valves strike on their seats and "bring up" with a jar and recoil that soon renders readjustment and repair necessary, and the recoil impairs their effect. If force be applied to counteract recoil, then they "bring up" the harder.

4th. By passing through, instead of on, the seat, these difficulties are obviated—the valve will wear longer without getting out of order, and the collars, or rims, allow it to vibrate (or work up and down) in the openings, still keeping them closed, which is not accomplished in the ordinary half stroke valve.

In the foregoing specification I claim as my invention, or improvement, the combination of two valves working in one stem, constructed as herein described, to wit: with rims, or collars, of sufficient depth to allow the requisite degree of motion while in their seats, and yet continuing to keep the openings closed, and with lugs, or guides, which prevent the valves from being displaced, and at the same time allow the steam to pass freely through the spaces between them.

WM. A. LIGHTHALL.

Notice of Tatham & Brothers Improved Manufacture of Lead, and other Soft Metal, Pipe.

Two patents have been granted within the last year to Messrs. Tatham & Brothers, of Philadelphia, for manufacturing pipes of lead and of other soft metals; the first of these was granted on the 29th of March, 1841, to John Tatham, Jr., and Henry B. Tatham, as assignees of the inventors of the apparatus used, Messrs. John and Charles Hanson, of Huddersfield, England; the last to George N. Tatham and Benjamin Tatham, Jr., of Philadelphia, for improvements on the foregoing; and this is dated on the 11th of October, 1841. An attempt was made in England, some twenty years ago, to manufacture lead pipes upon the same principle with that adopted in the apparatus of the Messrs. Tatham, and a patent was obtained for it; but the means then adopted for carrying the design into effect were defective, in consequence of which the article produced was imperfect, and the pipe never went into general use.

The usual method of manufacturing lead pipes is by first casting, and then drawing them, upon a suitable sized mandrel, through dies, by the aid of a draw-bench; until the introduction of Hanson and Tatham's machinery, this has been the only process successfully practiced in the United States. Although good pipe was frequently made by this method, it was not by any means uniformly so. It has not been found possible to keep the bore of the pipe in the centre of the mass of metal, and its strength was unavoidably unequal, from this cause. In the operation of casting, the metal sometimes becomes faulty in the interior, and such faults are extended in the act of drawing, and are not shown on the surface. The drawn pipes are usually from ten to sixteen feet only in length, and they have rarely been made of a greater diameter than two inches.

We have not only carefully examined the specification of Mr. Hanson's patent, and of that for the improvements devised by the Messrs. Tatham, but we have also seen, and critically inspected, many of the pipes manufactured by these gentlemen, and so far as a judgment can be formed by these means, the article may be pronounced to be perfect; the bore is truly centrical, the interior and exterior surfaces smooth and polished, the metal compact, and the length indefinite. With respect to their strength, we have conversed with the superintendent of the water works at Richmond, in Virginia, who has these pipes in use under a head of two hundred feet of water, has found them uniformly to bear this pressure, and in all respects

superior to other lead pipes. At the Baltimore water works also, we understand that they have been adopted, and are preferred.

We have delayed noticing the patents for this pipe in the expectation of receiving the report of the committee of the Franklin Institute thereon, which we are informed is altogether approbatory; this report we shall probably publish hereafter;* in the mean time it will be satisfactory to our readers to know something of the nature of the manufacture. The lead, or other soft metal, from which the pipes are to be made, is fused, and poured into a very strong metal cylinder, furnished with a piston, and it is suffered to cool therein sufficiently to become set, or to lose its fluidity. The piston is then forced down by means of a very powerful hydraulic press; by this pressure the metal is made to pass through four openings which surround a mandril, or core, on the outside of the cylinder head, and which is of the size of the intended bore; the four solid bars, or strips of metal, which are formed by these openings, are received within a funnel-formed cavity of steel, which surrounds the core, and by the enormous pressure to which they are subjected they are firmly welded together and made to pass out from a cylindrical opening in the funnel-formed cavity, in the state of a finished tube. The tubes thus made may be cut across into wafer-like pieces, which will exhibit a perfect juncture and continuity of the metal.

We do not attempt to describe the particular construction of the apparatus in its details, as this would require several engraved figures; the specifiations of the original patent, and of that for the improvements, have been drawn up with much care and clearness, and the claims appear to be made to a construction and arrangement of the parts which are new, and, as we believe, sustainable in law.

Progress of Practical & Theoretical Mechanics & Chemistry.

Adcock's Patent Spray Pump.

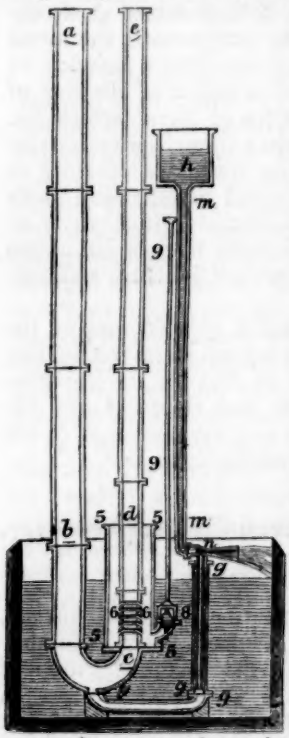
The following extract from a communication by Mr. Adcock, which appeared in the last number of the *Mining Journal*, fully illustrates the construction and action of his patent Spray Pump, of which we inserted a descriptive notice in a recent number.†

"This wood cut is intended to represent and explain a plan put down by me at the 100-yard shaft, at Pemberton, to relieve the bend pipe and lower part of the apparatus from any water that might, from accidental or other cause, be there collected; and as it answers the intended purpose well, I have no doubt that the wood-cut, and its descriptive account, will be gratifying to many of your readers.

"In the wood-cut *a b c* represent a part of the downcast pipe, or the pipe that conveys the air from the top of the pit, or the galleries and workings of the mine, through the bend pipe into the upcast; *b* to *c* the bend pipe, or that which unites at the bottom of the pit the downcast with the upcast; *c d e* the upcast pipe, or pipe through which the air, and the water commingled with it, is carried to the

* Published at p. 49 of this number. † See Jour. Frank. Inst. vol. ii, 3rd series, p. 380.

surface or top of the pit, that the water may be there again collected in a solid body, and thence be allowed to flow freely away; 6 6 represents five slits, through which the water flows from the sump or well at the bottom of the pit into the upcast pipe, when the apparatus is in action, that it may, by the current of air, be dispersed into drops, like drops of rain, and conveyed to the top. The downcast pipe is twenty-nine and a half inches diameter—the upcast pipe seventeen and a half inches; and when not working, and from causes which it is not necessary to explain, water leaks from the sump into the apparatus, to a height equal to the head of the water there, which is about eight feet from the bottom of the bend, or eight feet seven inches from the bottom of the pipe beneath the bend, consequently, the water rises to the same height in the pipe *g g g g*, which is four inches diameter; *m m* is a pipe, twenty feet long, that receives a supply of water from a water ring, placed so as to receive the water that oozes through and trickles down the sides of the pit. This pipe also is four inches diameter, but is unnecessarily large; it terminates in a compound cone marked *n*, as shown in the figure. Of the smaller cone the dimensions may be thus stated:—Its greater diameter, $\frac{96}{100}$th of an inch; its smaller diameter, $\frac{6}{10}$th ditto; and its length ½ ditto. Of the greater cone, the dimensions may be thus stated:—Its smaller diameter, $\frac{6}{10}$th of an inch; its greater diameter, $1\frac{1}{12}$th ditto; and its length $5\frac{4}{10}$th ditto. A pipe, $\frac{6}{10}$th of an inch diameter, descends from the junction of the larger cone with the smaller into the four inch pipe *g g g g*, as shown by the wood-cut. This pipe is nine feet long.



"Having thus given the proportions, I have only to describe the *rationale* of the contrivance:—The water in the pipe *m m*, is maintained by the water ring, or by the water that oozes through and trickles down the sides of the pit to a height or level equal to the height of the pipe itself, or twenty feet. Now, it is well known that the theoretic velocity of water, flowing out of an aperture, is equal to that of a heavy body falling from the height of the head of water, which is found, very nearly, by multiplying the square root of that height in feet by eight, for the number of feet described in a second. Thus, a head of one foot gives eight, a head of nine feet twenty-four, and a head of twenty feet thirty-five and three-fourths feet per second. This is the theoretical velocity; and from what is equally well known respecting the *vena contracta*, or the contraction which all streams undergo when passing through orifices, we must, in order to obtain the actual velocity, multiply the square

root of the height, in feet, by five instead of eight. It is equally well known, from the experiments of Venturi, Bryan Donkin, and others, that when water flows through a compound cone, as exhibited in the wood-cut, the quantity discharged, and, consequently, its velocity, is even greater than that due to the theoretic velocity. But as the twenty feet pipe, under consideration, terminates in an elbow, just before its junction with the double cone, I am quite willing, in order to prevent dispute, to consider the velocity of the water through the double cone as that due to the contraction of the stream. Hence $\surd 20 \times 5 = 22\frac{1}{2}$ feet per second, instead of $35\frac{3}{4}$ feet, as above stated.

I have already had occasion to remark, that the diameter of the suction pipe, nine feet long, which passes from the lower part of the double cone into the pipe, *g g g g*, is $\frac{6}{10}$th of an inch; hence the diameter of that pipe being $\frac{6}{10}$th of an inch, and the velocity of the water flowing over it, at its junction with the cone, twenty-two feet per second, the time occupied, or taken up, by any given particle flowing over its diameter, is $\frac{1}{440}$th part of a second—equal, decimally, to .00227 of a second.

"Now, by the laws of gravitation, the space through which a body will fall in a given time, in feet, is as the square of the time, in seconds, multiplied by $16\frac{1}{12}$. Hence, $.00227^2 \times 16\frac{1}{12} \times 12$ in. $= .0001$, very nearly, or about a thousandth part of an inch. Hence, by the laws of gravitation, and considering, at the same time, the expansion of the outward cone, from $\frac{6}{10}$ to $1\frac{1}{12}$ inch diameter, and that, too, in a length of $5\frac{4}{10}$th inches, there is not time, in the passage of the water over the orifice of the $\frac{6}{10}$th inch pipe, for any portion of it to fall into that pipe; hence, as the water flows over the orifice of that pipe with rapidity, it, by its friction or adhesion, or the lateral communication of motion in fluids, withdraws from it some portion of the air, and, subsequently, of the water, so as to produce a partial vacuum. The weight of the atmosphere, in the downcast and upcast pipes of the patented apparatus, then comes into play, and forces the water in those pipes continuously from the pipe, *g g g g*, up the $\frac{6}{10}$th inch pipe, and then through the larger cone, until the surface of the water in the bend pipe, *b* to *c*, gets below the level of the nine feet pipe, and, consequently, is below the bottom of the bend. Thus, Mr. Editor, without valves, clacks, pumps, or any thing that can get out of order, is this important object effected.

HENRY ADCOCK, Civil Engineer.

June 21, 1841.

Mechanics' Magazine, July, 1841.

NOTICES FROM THE FRENCH JOURNALS. TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE, BY J. GRISCOM.

New Motive Power.—The Force of Trees agitated by the Wind.

The idea of turning to account, as a mechanical force, the oscillations of a tree by the wind, has never been proposed, because no one,

it is probable, has ever deemed it to be a practicable source of power. A very considerable force, the least costly of all, is thus entirely lost. An attempt has been made to bring it into use by Count de Masing and Paulin Desormeaux, and if they have succeeded, as the ingenious apparatus exhibited at the "*Exposition*" would seem to prove, they will have rendered an immense service to the public, and especially to the inhabitants of the country.

The great difficulty which the inventors have to overcome is to convert into a regular rotary and continuous movement the incoherent and vagabond oscillations of currents of wind issuing from all points of the horizon, and often varying with such rapidity as to box the whole compass in the course of five minutes. The movement must necessarily be double, namely, that arising from the wind and the contrary one from the elasticity of the tree. By reducing the question to its simplest expression, in placing the tree in the centre of a triangle we have three points for the motion of the wind, and three others opposite for the motion of elasticity. The authors have sought to economise by reducing to five the number of their organs; in placing the tree in the centre of a pentagon. From whatever quarter the wind comes and the tree rectifies itself, a lever of the third kind is moved, which transmits its motion by a particular mechanism, to an imbedded arbor, which always turns in one direction, and by means of toothed wheels, bands, or otherwise, transmits the motion to the working apparatus. Hence, in whatever way the tree may move, the work is always going on; and it is only in periods of absolute calm that it ceases to act, being in this respect like the sails of a wind mill or a water wheel during a drought.

The King and all his family had this machine explained to them. It is so simple as to cost in the erection but 250 francs. When a convenient tree is wanting, a flexible pole may be erected on a roof, so as to transmit to the interior its motion by the wind, without any of the trouble of adjustment to the wind, reefing, unreefing, or other preparatories requisite in the common machines.

Recueil, Soc. Polytech.

On the Force of Tension of some Condensed Gases.

By M. Bunsen, (Ann. de Pog.)

I first measured the resistance of the glass tubes to be employed. They were entirely filled with water, a small manometer being previously introduced, and then immersed in water heated gradually to boiling, or 100°. This, from the tendency to expansion of the internal water, represents a pressure of 150 atmospheres. When the tubes burst under such a pressure an infinity of longitudinal and parallel fissures were produced, and a sharp sound was heard.

A tube 11⅓mm. diameter and 1⅓mm. thick, burst under a pressure of eighty atmospheres, and I have found tubes of smaller diameter which resisted 200 atmospheres. But in time their tenacity is so diminished that some which had sustained thirty atmospheres have suddenly burst with a pressure of scarcely four atmospheres. I attri-

bute this to a diminution of elasticity like that of other bodies, maintained for some time under strong pressure.

Sulphurous acid, cyanogen and liquid ammonia, subjected to pressure in glass tubes containing a manometer, furnished the following tensions calculated in metres of mercury.

Temperatures.	Sul. Acid.	Cyanogen.	Ammonia.
—33.7°			0.949m
—30.0			
—25.0			
—20.0		0.80	
—15.0		1.10	
—10.0	0.78	1.41	
— 5.0	1.11	1.73	3.64
0	1.48	2.07	3.61
+ 5.	1.91	2.44	4.26
+10.	2.89	2.88	4.98
+15.	2.93	3.33	5.78
+20.	3.54	3.80	6.67
+25.	4.20	"	"

Sulphurous acid boils at 10.5° under a baromatic pressure of 0.744m.

Cyanogen becomes liquid at 25°C., and begins to solidify at 30°, assuming a radiated texture. Its boiling point is 20.7° C.

Ammonial gas should be perfectly dried before being liquified. Its boiling point is 33.7° C.

I have tried in vain to liquify by a reduction of temperature as far as 50°, the gas which results from the combination of hydrogen with Chlorine, bromine, iodine and phosphorus.

We may obtain sulphuretted hydrogen in a liquid state by subjecting hyper sulphuret of hydrogen to decomposition in a tube; but for this purpose the presence of a little water is necessary. If we introduce a few pieces of chloride of calcium in tubes, the hyper sulphuret may be preserved intact while the tube remains hermetically closed.

Ann. des Mines, tome 18, Liv. 2, 1840.

Ductility of Glass.

The conservator of the museum of Avignon has remarked that all the glass vases found buried at Vaison, were so soft and ductile when first discovered that they might be kneaded up and cut with a knife blade, but that they resumed the fragility and hardness of common glass after a few hours exposure to the air. This remark applies only to the vases buried at a depth of at least three metres. Ibid.

Decomposition of Organic Substances, by Barytes. By Pelouze and Millon.

Anhydrous barytes removes from organic substances all the carbonic acid which their elementary composition affords; hydrated barytes carries the destruction farther and tend to burn out the carbon, while the hydrogen which proceeds from the substance unites with that coming from the decomposition of the water and is disengaged in a free state. Ibid.